REMOVAL OF HAZARDOUS CONTAMINANTS (HCs) IN THE HAMILTON WPCP

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Water Resources Branch

REMOVAL OF HAZARDOUS CONTAMINANTS (HCs) IN THE HAMILTON WPCP

Submitted to:

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Ontario Ministry of the Environment

By:

CANVIRO CONSULTANTS LTD.

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PREFACE

This study was carried out in the Hamilton Water Pollution Control Plant (WPCP) in 1982-83. With funding provided by the Ontario Ministry of Environment and Environment Canada. Study results have been reported in the following publications:

Ministry of Environment, 5th Annual Technology Transfer Conference, Toronto, 1983.

Ministry of Environment, 6th Annual Technology Transfer Conference, Toronto, 1984.

The Final Report has gone through a detailed process of Peer Review to ensure that interpretation of study results and conclusions presented in the report are accurate.

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1.0 INTRODUCTION

1.1 Background and Relevance

In the modern industrial society hazardous contaminants (HCs), both toxic metals and toxic organic compounds are discharged into public sewage systems. Until very recently, relatively little was known about the identities and quantities of the contaminants entering wastewater treatment plants and little information was available on the factors which would influence their treatability and ultimate fate. Therefore, increased concern has resulted regarding the possible long term environmental and health risks associated with:

(a) Typical municipal and industrial waste treatment practices.
(b) Common sewage sludge and other solid waste disposal methods such as landfilling, landspreading and incineration.
(c) The need to reclaim water from treated effluents for reuse.

Many governments have passed legislation and established agencies to control the discharge of specified hazardous substances into the environment.

In Canada, under the terms of the Environmental Contaminants Act 1976, the substances of concern have been compiled into the List of Priority and Candidate Chemicals (Table 1). Review of this list is an on-going process and updates are published by the Environmental Protection Service (EPS) in the Canada Gazette.

In the United States, the regulation and monitoring of environmental contaminants focus on a list of 126 substances known as Priority Pollutants (Table 2).

According to such researchers as Chaney (1980) and Dacre (1980) these pollutants are of concern because:

1. Exposure to some metals above specific tolerance levels can result in toxic effects in plants, animals and humans.
2. Some trace metals are taken-up by plants and may subsequently be consumed by animals and humans.

TABLE 1. CANADIAN ENVIRONMENTAL CONTAMINANTS ACT
LIST OF PRIORITY AND CANDIDATE CHEMICALS
(Canada Gazette January 16, 1982)

PRIORITY CHEMICALS

Category I: Those substances which are in the Schedule to the Act and for which further regulations or specific control strategies are being developed.

Polychlorinated Biphenyls (PCBs), Chlorofluorocarbons (CFCs)

Category II: Those substances which are being investigated to determine the nature and the extent of the danger to human health or the environment and the appropriate means to alleviate that danger.

Cadmium
Chlorophenols

Category III: Those substances which may pose a significant danger to human health or the environment and about which further detailed study or information (for example toxicology, amounts used or concentrations in the environment) is necessary.

Chlorobenzenes
Hexachlorobutadiene (HCBD)
Dodecachloropentacyclooctadecadiene (CAS No. 13560-89-9)
Organotins
Phthalic Acid Esters
Chlorinated Paraffins (CAS No. 63449-39-8)
Chloroethanes
Chloroethylenes
Chloromethanes

CANDIDATE CHEMICALS

The list of Candidate Chemicals indicates potential environmental contamination problems where the degree of concern is insufficient to warrant placement in the List of Priority Chemicals.

Triarylphosphates and Related Substances
Aromatic Amines e.g. (i) diphenylamine and derivatives
(ii) aminobiphenyls and derivatives
(iii) aniline and some derivatives
Halogenated Diphenyl Ethers
Halogenated Toluenes

Compounds for which regulations are in force under the Act.

Polychlorinated Biphenyls (PCB), Mirex
Polybrominated Biphenyls (PBB), Polychlorinated Terphenyls (PCT)
Chlorofluorocarbons

Chemicals that are used solely as drugs, food additives or pesticides are excluded from the Priority and Candidate Chemicals List because they are already scrutinized or controlled under other federal legislation. Similarly, the following environmental contaminants are being controlled or investigated under legislative mandates other than the Environmental Contaminants Act.

Arsenic
Asbestos
Benzene
Lead
Mercury
Oxides of Nitrogen
Oxides of Sulphur
Polynuclear Aromatic Hydrocarbons

TABLE 2. EPA PRIORITY POLLUTANT LIST

TRACE ORGANICS

VOLATILE ORGANICS GROUP

- Benzene
- Bromodichloromethane
- Bromoform
- Bromomethane
- Carbon Tetrachloride
- Chlorobenzene
- Chloroethane
- 2-Chloroethylvinyl ether
- Chloroform
- Chloromethane
- Dibromochloromethane
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1-Dichloroethylene
- trans-1,2-Dichloroethylene
- 1,2-Dichloropropane
- 1,2-Dichloropropene
- cis-1,3-Dichloropropene
- trans-1,3-Dichloropropene
- Ethylbenzene
- Methylene Chloride
- 1,1,2,2-Tetrachloroethane
- 1,1,2,2-Tetrachloroethene
- Toluene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Trichloroethylene
- Vinyl Chloride

SEMI-VOLATILE ORGANICS GROUP

Base-Neutrals

Polynuclear Aromatic Hydrocarbons, including
- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Benzo(a)pyrene
- Chrysene
- Dibenzo(ah)anthracene
- Fluoranthene
- Fluorene
- Indeno (1,2,3-cd) pyrene
- Naphthalene
- Phenanthrene
- Pyrene

Chlorinated Benzenes, including
- 1,2-Dichlorobenzene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- Hexachlorobenzene

Nitrosamines, including
- N-nitrosodimethylamine
- N-nitrosodiphenylamine
- N-nitrosodi-n-propylamine

Phthalate Esters, including
- Butyl Benzylphtnalate
- Di-n-butylphthalate
- Diethylphthalate
- Dimethylphthalate
- Di-n-octylphthalate
- bis-(2-ethylhexyl)phthalate

Haloethers, including
- 4-Bromophenyl phenyl ether
- bis (2-chloroethoxy) methane
- bis (2-chloroethyl) ether
- bis (2-chloroisopropyl) ether
- 4-Chlorophenyl phenyl ether

Other compounds, including
- Benzidine
- 2-Chloronaphthalene
- 3,3'-Dichlorobenzidine
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- 1,2-Diphenylhydrazine
- Hexachlorobutadiene
- Hexachlorocyclopentadiene
- Hexachloroethane
- Isophorone
- Nitrobenzene

Acids
- p-Chloro-m-cresol
- 2-Chlorophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 4,6-Dinitro-o-cresol
- 2,4-Dinitrophenol
- 2-Nitrophenol
- 4-Nitrophenol
- Pentachlorophenol
- Phenol
- 2,4,6-Trichlorophenol

Pesticides and PCBs
- Aldrin
- alpha-BHC,
- beta-BHC
- gama-BHC (Lindane)
- delta-BHC
- Chlordane
- 4,4'-DDD
- 4,4'-DDE
- 4,4'-DDT
- Dieldrin
- alpha-Endosulfan
- beta-Endosulfan
- Endosulfan Sulphate
- Endrin
- Endrin Aldehyde
- Heptachlor
- Heptachlor Epoxide
- PCB-1016
- PCB-1221
- PCB-1232
- PCB-1242
- PCB-1248
- PCB-1254
- PCB-1260
- Toxaphene

MISCELLANEOUS GROUP
- Acrolein
- Acrylonitrile
- 2,3,7,8-tetrachlorodibenzo-p-dioxin
- Asbestos
- Cyanide
- Total Phenols

TRACE ELEMENTS
- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Zinc

3. Some trace organics:
   a) have very low water solubility,
   b) do not degrade readily in soil,
   c) have high affinity for lipids and bioaccumulate in tissue,
   d) accumulate and translocate in the food chain,
   e) are highly toxic to mammals, and
   f) are carcinogenic, mutagenic and teratogenic.

In response to environmental and health concerns, the study described herein and other recent research has been directed to determining the effectiveness of current wastewater treatment technology in removing toxic contaminants from municipal and industrial liquid waste. In addition, the mechanisms of contaminant treatment and contaminant fate have also been addressed in some of these studies. Recently published reports include four dealing with large scale field surveys and two based on studies of pilot-scale wastewater treatment facilities:

1. Survey of 40 Publicly Owned Treatment Works (POTW) by U.S. EPA Effluent Guidelines Division (EPA 1982a).
2. A 30 day study at a POTW by U.S. EPA Effluent Guidelines Division (EPA 1982b).
3. Survey of 25 POTW by U.S. EPA Municipal Environmental Research Laboratory (MERL) (Cohen et al 1981).
4. The 5 plant study by the Chemical Manufacturers Association (CMA) and the U.S. EPA (CMA/EPA 1982).

   U.S. EPA MERL pilot plant studies of semi-volatile organic compounds (Petrasek et al 1980 and 1981).
6. Pilot plant study of a group of volatile and semi-volatile organic compounds by van Rensburgh et al (1980) of the National Institute for Water Research in South Africa.

Bishop (1982) and Meicer (1982), have summarized and discussed selected data from some of these recent EPA reports. Results from the EPA surveys and pilot plant studies indicated that the wastewater treatment processes studied were stable over a wide range of operating conditions and were generally effective in removing toxic substances, as shown in Table 3.

TABLE 3. EXAMPLES OF TOXICS TREATMENT EFFICIENCY IN MUNICIPAL TREATMENT PLANTS

STUDY	REFERENCE	TREATMENT EFFICIENCY
40 POTW Survey	EPA (1982a)	For half of the POTWs studied: 70% for metals 82% for volatile organics 65% for base-neutral organics
25 POTW Survey	Cohen (1981)	>80% for many organics
Pilot Plant Study	Petrasek (1981)	>90% for the semi-volatiles studied

Individual inorganics; e.g. As, Cd, Cu, Hg and Pb, and organics; e.g. polynuclear aromatic hydrocarbons (PAHs) and pesticides pass through a substantial number of treatment plants in sufficient amounts and with sufficient frequency to be probable cause for concern.

As influent concentrations of many conventional and priority pollutants increased, effluent concentrations also increased. This implies that the removal rates for the priority pollutants were relatively constant and that a fixed percentage of the loading of these pollutants was removed by secondary treatment.

In general, the higher the industrial contribution to a POTW, the higher the concentration of priority pollutants in the POTW influents. Heavy rainfall increased metallic priority pollutant mass loading at POTWs while the mass loading of both metallic and organic priority pollutants in POTW influents was higher on weekdays than on weekends.

Some pollutants not detected in POTW influents were regularly measured at high levels in the corresponding sludge streams; e.g. PAHs and phthalates which were concentrated to the greatest degree in sludges. In this regard, the survey data [EPA (1982a) and Cohen (1981)] support the findings of Petrasek (1981), who has suggested that sludges, particularly primary sludges are likely to act as a sink for these compounds because of a bioconcentration effect.

Van Rensburg et al (1980) reported from their South African study, 90 percent effectiveness in the removal of toxic organics under shock loadings and a concentrating effect of some contaminants in the recycled sludge. Both of these observations are in agreement with those reported in the U.S. EPA surveys and pilot-scale studies (EPA 1982a, Cohen 1981 and Petrasek 1981).

Several similar and related studies have been performed or are in progress in Canada. Toxic organics discharged from nine Ontario sewage treatment plants have been determined (Munroe et al 1982) and studies of the fate of trace organics in a continuous flow pilot plant at the Wastewater Technology Centre (WTC) in Burlington, Ontario are on-going (Melcer 1983).

In a recent review of thirty municipal wastewater treatment facilities in the Great Lakes Basin (CANVIRO 1983), it was concluded that the existing data base for toxics removal was inadequate for many of the thirty treatment plants surveyed. Zinc and chromium were identified as the most commonly occurring toxic contaminants present at elevated levels in influents, effluents and sludges. While nickel, copper, cyanide, phenols and volatile organic compounds were also identified as potential areas of concern.

Hamilton WPCP serves the Region of Hamilton-Wentworth which includes the City of Hamilton with a population of about 300,000. Hamilton-Wentworth is a heavily industrialized region in Southern Ontario with two large steel mills which produce more than 60% of Canadian steel. In addition, some large chemical manufacturers are also located in the treatment plant catchment area.

In a screening study, Craig et al (1980) identified thirty-six major trace organic contaminants in the Hamilton WPCP final effluent. Weiler et al (1980) found an accumulation of PCBs, pesticides and metals in the Hamilton Harbour. In view of the importance of the concerns about water quality and reuse, there was a need to monitor the Hamilton WPCP final effluent and to relate the HCs in the effluent to concentrations in the influent and overall treatment plant efficiency.

In August 1982, CANVIRO was retained by the MOE to perform a monitoring study at the Hamilton WPCP.

1.2 Study Objectives

The overall objective of the monitoring program was to provide an accurate estimate of the annual loading of hazardous contaminants (HCs) entering into and being discharged from the Hamilton WPCP. This would allow estimates of the present sewage treatment process efficiency and factors influencing HCs removal to be determined.

Other specific objectives of the study were:

1. Develop treatability/removability data for HCs in a conventional activated sludge treatment process.
2. Relate HC removal efficiency to process operations such as solids retention time (SRT).
3. Determine and comment on likely removal mechanisms for HCs in the study based on a review of the available literature and the known chemical and physical properties of the contaminants.
4. Determine the levels of recycled HCs in the plant.
5. Identify any seasonal effects such as the Spring freshet or seasonal temperature differences on the levels and treatment of HCs entering the plant.

1.3 Study Approach

Analytical problems have been reported in most of the toxic studies conducted to date (e.g. EPA 1982a and CMA/EPA 1982). The study was therefore divided into two phases with a strong emphasis in Phase 1 being placed on the verification of sampling techniques, analytical methods development and an intensive Quality Assurance/Quality Control (QA/QC) program.

At the onset of Phase 1, a short list of HCs was prepared by MOE for the two phases of work. Contaminants were selected using existing MOE analytical data for the Hamilton WPCP and the results of screening analyses performed by CANVIRO during a separate study for EPS (CANVIRO 1983).

The contaminants selected include:

1. Trace Organics - Polynuclear Aromatic Hydrocarbons (PAHs)
   - Total Polychlorinated Biphenyls (PCBs)
   - Pesticides
2. Heavy Metals
3. Conventional Pollution Parameters

The important criteria which influenced contaminant selection were:

1. Contaminant Concentration - It was necessary that contaminants be present in both the influent and effluent streams at levels that would permit their satisfactory measurement.

2. The Availability of Analytical Methods - In order to avoid long delays and costly research, it was necessary that suitable analytical methods must be capable of measuring the selected contaminants in both the influent and the effluent with a high degree of precision and accuracy in order to satisfy the objectives of the study.
3. Environmental Significance - The contaminants were selected in light of current scientific knowledge and public concerns about their health and environmental effects.

The PAH group of trace organics was the primary focus of the study, particularly during the methods development and QA/QC work of Phase 1. The eight compounds included in this group are presented in Table 4, together with their chemical structures and some physical data. By strict definition, carbazole and dibenzofuran are polynuclear heterocyclic compounds; however, since they are structurally and chemically related to PAHs, they were included in this group for the purposes of the study.

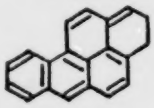
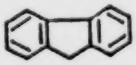
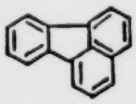
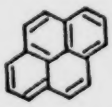
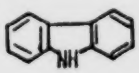
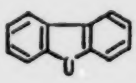
The environmental significance of these compounds can be summarized briefly as follows:

PAHs have been designated as priority pollutants by the U.S. EPA and in Canada they are included in the Water Pollution Control Directorate (WPCD) list of suspect/priority toxic chemicals. PAHs are probably the most widespread of all environmental contaminants (Jones and Leber 1979) and they have been frequently identified in both Canadian and U.S. municipal treatment plants (Bridle 1982 and EPA 1982a). This group of compounds are non-polar and bioresistant. They have an affinity for lipids, and therefore, tend to bioaccumulate (Zedeck 1980). PAHs have been known to be carcinogenic for about fifty years (Thakker et al 1979), and although structurally similar, have widely varying degrees of carcinogenicity (Daniel et al 1979). Benzo(a)pyrene is an important member of this class of compounds which produce serious cytotoxic, mutagenic and carcinogenic effects in many species and tissues (Jones et al 1979).

The sampling and analysis procedures established during Phase 1 provided the necessary foundation for the WPCP Monitoring Program, which was performed in Phase 2 during the period December 1982 - August 1983.

In this, the Final Report, a detailed description of the Phase 1 and Phase 2 procedures, results and conclusions are presented.

TABLE 4. STRUCTURAL AND PHYSICAL DATA FOR PAH GROUP OF TRACE ORGANICS

COMPOUND NAME	COMPOUND STRUCTURE	MELTING POINT °C	BOILING POINT °C	VAPOUR PRESSURE AT 20°C torr	SOLUBILITY IN WATER AT 25°C mg/L	LOG OCTANOL/ WATER PARTITION COEFFICIENT
Acenaphthylene		92.3	265.8	10^{-3} - 10^{-2}	3.93	4.33
Benzo(a)pyrene		177	495	5 x 10^{-9}	0.0038	6.04
Fluorene		116-7	293-5	10^{-3} - 10^{-2}	1.98 1.69	4.18
Fluoranthene		111	375	10^{-6} - 10^{-4}	0.26	5.33
Naphthalene		80.5	218	0.0492	34.4 31.7	3.37
Pyrene		156	393	6.85 x 10^{-7}	0.14 0.132	5.32
Carbazole		247-8	355	N.A.	N.A.	N.A.
Dibenzofuran		86-7	287	N.A.	N.A.	N.A.

Notes: NA = Data Unavailable

2.0 EXPERIMENTAL PROGRAM - PHASE 1 AND PHASE 2

2.1 Experimental Design

The design of the experimental program is depicted in Figure 1.

Twenty-four hour composite samples were collected on two occasions in Phase 1 and during three separate periods in Phase 2, as shown in Table 5.

TABLE 5. PHASE 1 AND PHASE 2 SAMPLING PROGRAM

PHASE	SAMPLING PERIOD	NUMBER OF SAMPLING DAYS
1	August - September 1982	2
2		
Winter	December 1982 - January 1983	6
Spring	April and May 1983	4
Summer	June - August 1983	4

The following samples were collected:

1. Combined influent; raw sewage combined with the in-plant return stream.
2. Effluent.
3. Waste activated sludge (WAS).

The in-plant return stream was also sampled on an intermittent basis. The WPCP operation was observed closely during the sampling periods and the process data together with observations of WPCP operational upsets were recorded for correlation with the analytical results for the parameters being measured.

This study was unique, in that the solid and liquid fractions of the samples were examined separately. Therefore, the samples were centrifuged to separate the two fractions prior to analysis. However, the suspended solids concentration of the effluent was extremely low, and in order to avoid centrifuging very large volumes of effluent, WAS solids were used instead.

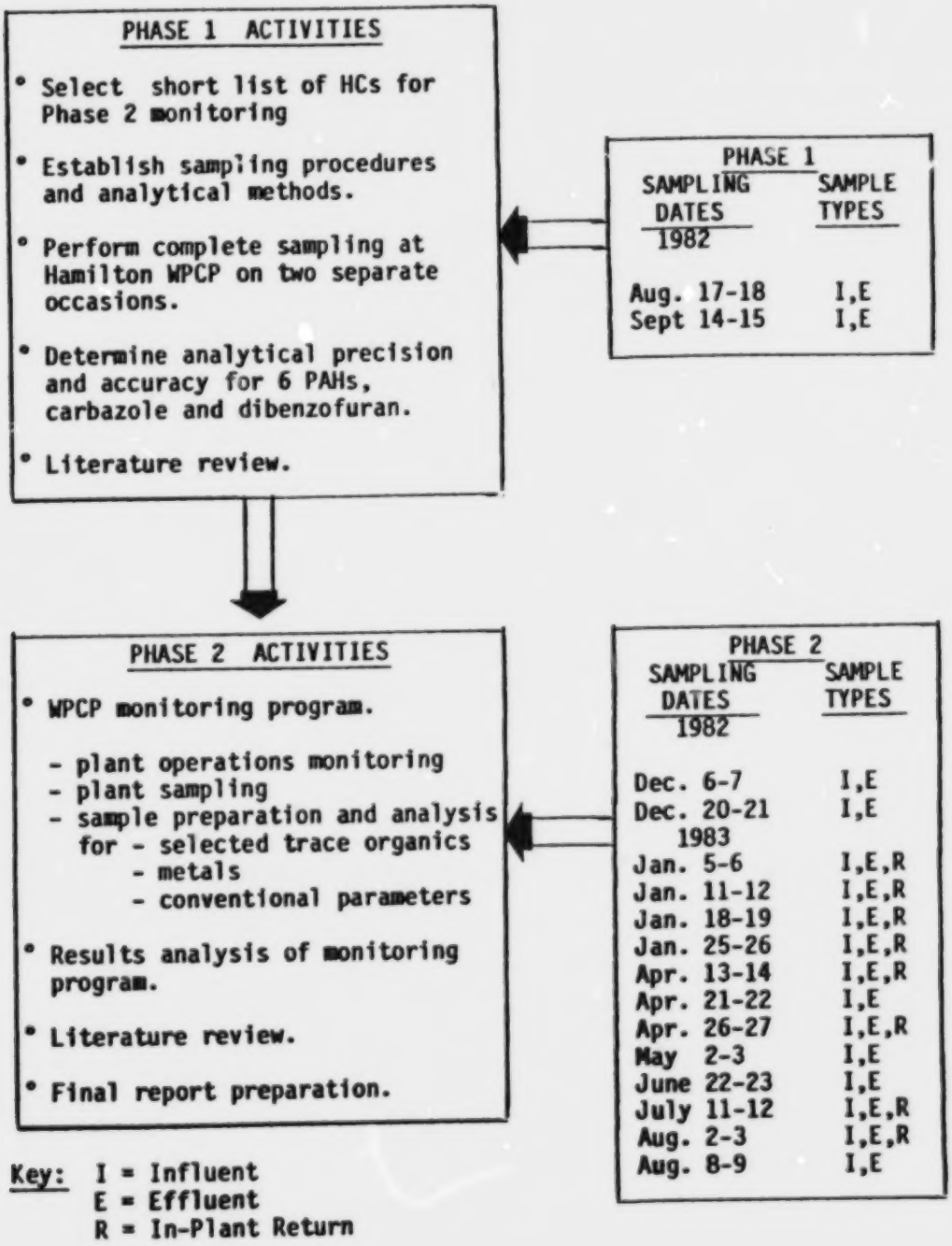


FIGURE 1 - DESIGN OF EXPERIMENTAL PROGRAM

In the original experimental design, it was anticipated that the majority of the QA/QC work for this study would be accomplished during Phase 1. Therefore, it was hoped that the methods development and intensive analytical QA/QC program performed for the PAH group during Phase 1 would not only provide:

i) development and refinement of the analytical method for PAHs, and
ii) proper definition of the precision and accuracy of the selected procedures for the analysis of PAHs, but also
iii) provide compound recovery data which could be used in conjunction with the Phase 2 results.

Thus, provided that an acceptable minimum of routine QA/QC was performed during Phase 2, the primary focus of the Phase 2 work would be the WPCP monitoring program. However, because of the complex nature of the samples, particularly the influent samples, high levels of interferences were observed in the final extracts, and therefore, it was decided to maintain a fairly high level of QA/QC throughout the study. Although this was done at the expense of reducing the amount of planned WPCP monitoring, it is felt that improved results were obtained.

2.2 Testing Procedures

2 Hamilton WPCP Description and Sample Locations

The Hamilton WPCP is a conventional WAS plant, with design features and layout as depicted in Figure 2. The design summary provided in Figure 2 shows not only the design capacity and recommended operating parameters, but also a summary of the systems' performance as monitored during a previous CANVIRO study (CANVIRO, 1983).

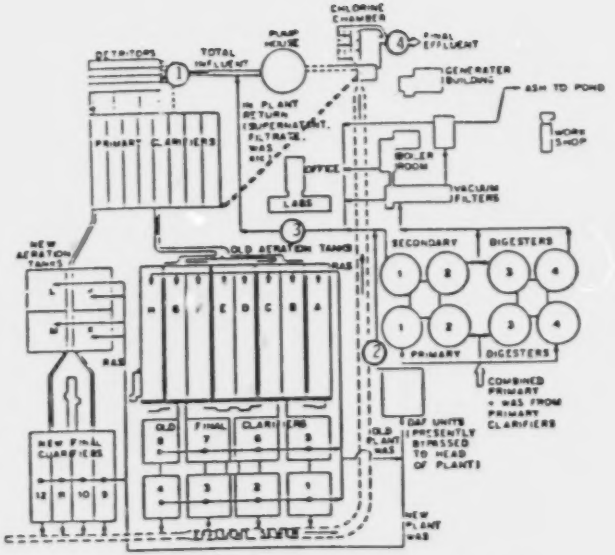
The plant receives a combined wastewater influent of raw sewage and in-plant returns, at a design flow rate of 408,420 m^3/d. During the study, samples of this combined influent were taken at the location designated by sampling point 1 in Figure 2. Immediately downstream from sampling point 1, the influent passes through a preliminary treatment section which consists of 4 mechanically raked bar screens and subsequent detritor units. The wastewater then enters a group of primary clarifiers where primary settling occurs.

FIGURE 2. SUMMARY OF PLANT CONFIGURATION, DESIGN EVALUATION AND SAMPLING LOCATIONS FOR THE HAMILTON WPCP.

MUNICIPALITY: HAMILTON, ONTARIO

TREATMENT FACILITY: CONVENTIONAL SECONDARY

OPERATING AUTHORITY: REGION OF HAMILTON-WENTWORTH



PROCESS FLOW SCHEMATIC OF HAMILTON WPCP

○ - SAMPLING LOCATION

PARAMETER	DESIGN (mg/L)	REQUIREMENT (mg/L)	(kg/d)
BOD_5	200	15	6126
SS	250	15	6126
Total P	7.5	1.0	408

DESIGN EVALUATION

Flow: Design - 408,420 m^3/d
(272,280 m^3/d old,
136,140 m^3/d new)
1981 - 265,700 m^3/d
(182,600 old,
81,100 m^3/d new)
Collectin System: (both proportions unknown)
Wastewater Sources:
Sanitary: % unknown
Industrial: % unknown
I/I: % unknown

Preliminary Treatment

Screening: Four mechanically raked bar screens.
Raw Sewage Pumps: Five vertical shaft centrifugal pumps rated @ 181,600 m^3/d each
One v.s. centrifugal pump @ 190,000 m^3/d
Grit Removal: Four 10.7 m detritor units
Design HRT: 1.2 min

Primary Clarifiers

Number of Tanks: Eight
Dimensions: 76.3 m x 12.5 m x 3.2 m
Total Volume: 24,690 m^3
Total Surf. Area: 7617 m^2

	Design	1981
Ret. Time:	2.2 hr	1.8 hr
Surface Settling Rate:	35.7 $m^3/m^2/d$	34.8 $m^3/m^2/d$
Weir Rate:	172 $m^3/m/d$	166 $m^3/m/d$

Aeration System

	Old	New
No. of Cells	Eight	Four
Aerator	45 kw	45 kw
Cell Dimen.	18.3 x 18.3 x 4.6 m	16.5 x 16.5 x 4.6
Total Volume	68,100 m^3	20,880 m^3
HRT. - Design	6.0 hr	5.7 hr
- 1981	9.0 hr	6.2 hr

Secondary Clarifiers

	Old	New
No. of Tanks:	Eight	Four
Dimensions:	36 x 36 x 3.6 m	73.2 x 18.3 x 3.6 m
Total Volume:	39,120 m^3	19,560 m^3
Total Surf. Area:	10,370 m^2	5,344 m^2
Retention Time:		
- Design	3.4 hr	3.4 hr
- 1981	5.1 hr	5.8 hr
Surf. Sett. Rate:		
- Design	25.4 $m^3/m^2/d$	25.4 $m^3/m^2/d$
- 1981	17.1 $m^3/m^2/d$	15.2 $m^3/m^2/d$
Weir Rate:		
- Design	297 $m^3/m/d$	297 $m^3/m/d$
- 1981	Unknown	Unknown

Chlorination

Contact Time: Design - 30 min
: 1981 - 41.5 min
Dosage: 2.2 mg/L

Phosphorus Removal

Chemical: None added

Sludge Production and Handling

Production: 3.9 m^3/1000 m^3 influent (without P removal)
Return Sludge: 408,600 m^3/d
Raw Sludge Pump Capacity: 1.36 m^3/min
Waste Sludge Pump Capacity: 40,800 m^3/d

Vacuum Filtration:
No. of Filters: Four
Total Area: 186 m^2
Solids Throughput
: Design - 39 kg/hr/m^2
: 1981 - 39 kg/hr/m^2

Digesters:
No.: Four primary; Four secondary
Total Volume: 63,520 m^3
Primary Digester HRT
: Design - 14 days
: 1981 - 23 days
Primary Digester Solids Loading
: Design - Unknown
: 1981 - 1.03 kg VS/m^3/d

Incineration:
Two multiple hearth incinerators designed for 10 T cake/hr at 20% T.S. (2 T ds/hr).

Disposal

3520 tonnes D.S./year.
Ash hauled to landfill.

OPERATIONAL EVALUATION (1981)

Detrimental Factors

1. Existing primary clarifiers are frequently overloaded hydraulically as they were designed for 272,280 m^3/d, and average daily flow is 97% of design. High effluent SS and BOD_5 result from heavy rains.
2. Influent return flows are very high in SS causing solids overloading in clarifiers.
3. No phosphorus removal chemical is added.
4. Flow to the two sides of the plant is often poorly distributed.
5. Heavy industrial input to plant.

Beneficial Factors

1. High concentration of iron in wastewater helps phosphorus removal.

1981 AVERAGES FOR KEY OPERATIONAL PARAMETERS

Hydraulic Retention Time(HRT): 8.1 hrs
Solids Retention Time (SRT): 2.5 d
F/M: 0.21
Return Rate: 110%
Phosphorus Removal Chemical Dose: none
Bypass Flow: Frequency = 28 occasions
Average Duration = 19 hr
% of Flow = unknown

Upon discharge from the primary clarifiers, the flow splits before entering the aeration basins for biological treatment. Approximately 272,280 m^3/d is directed to an original 8 tank aeration system, while the remainder (136,140 m^3/d) of the flow is routed to a more recently constructed 4 tank aeration system. Final clarification takes place in the secondary settlers which produce a clear liquid effluent. The effluent is then discharged to the chlorine chamber for disinfection. Chlorination was only practiced between May to November. Part of the settled solids mass (activated sludge) is returned from the final clarifier underflow to the aeration basins (return activated sludge; RAS) and the remainder (waste activated sludge; WAS) is combined with other in-plant returns which flow to the head of the plant. The activated sludge was sampled from a pipe prior to the return sewer before it had an opportunity to mix with other returns (see sampling point 2, Figure 2).

Primary and waste activated sludge which settles in the primary clarifiers is pumped to anaerobic digesters for stabilization. Dewatering of the digested sludge is accomplished through vacuum filtration after which the dry solid is incinerated and the resulting ash is settled in a pond. Return of the digester supernatant, vacuum filter filtrate and incinerator ash quenching water to the primary clarifiers is accomplished via the in-plant return sewer. Intermittent samples of the combined return were taken at the location designated by sampling point 3 in Figure 2. Following chlorination, the treated water is discharged and leaves the plant through the effluent channel. The fourth and final sampling point for the study was located in this effluent conduit as shown in Figure 2.

2.2.2 Sample Collection and Preparation

On each sampling date, twenty-four hour composite samples of combined influent (150 litres), final effluent (20 litres) and waste activated sludge (20 litres) were collected. On some sampling occasions, a twenty-four hour composite sample of the in-plant return flow (50 litres) was also collected. Four Isco Model 2100 samplers were used to collect the samples and appropriate flow measuring gear was used to obtain the flow volumes during the sampling periods. The samples, however, were not flow-proportioned.

At the WTC, a portable mixer fitted with a stainless steel shaft and impeller was used to thoroughly mix the large influent sample. During mixing, subsamples (1 litre) of the influent were removed for submission for the analysis of conventional parameters. The remaining sample was then centrifuged using a Westfalia Continuous Flow Centrifuge. The liquid centrate was collected in a clean glass jar (20 litres) and then subdivided for the various chemical analyses. The solid fraction was removed from the stainless steel bowl of the centrifuge and stored in a glass jar (4 litres). The samples of effluent and in-plant return were processed in a similar manner except that sample mixing was done by hand-shaking or stirring. In the case of the WAS sample, only the solids fraction was required, and therefore, the centrate was discarded.

Care was taken to clean the centrifuge bowl and flush all lines with water and acetone between samples.

All sample bottles and jars were carefully boxed and then transported to the CANVIRO office in Kitchener, where they were refrigerated until needed.

The solids fraction of influent, in-plant return and WAS required additional centrifuging prior to being submitted for analysis. This was done by transferring portions of the solids to stainless steel centrifuge tubes (250 mL) and centrifuging at 10,000 rpm for five minutes in a refrigerated laboratory centrifuge (IEC 204). The liquid fraction was discarded and the wet solids were subdivided for the various analyses.

2.2.3 Sample Bottle Types and Cleaning Procedures

Recommended (EPA and MOE) sample containers and equipment were used at all critical stages of the study. Most sample bottles were supplied by MOE, prepared ready to use. Other bottles and equipment supplied by CANVIRO were prepared for use by overnight soaking in solutions of Contrad 70, a patented phosphate-free laboratory cleanser. The equipment was then thoroughly rinsed in tap and double distilled water. Glass, stainless steel and teflon items were baked overnight in an oven at 150°C.

2.2.4 Analytical Procedures

2.2.4.1 General

Chemical analyses were performed to determine:

i) Six PAHs and two related compounds:

Acenaphthylene	Naphthalene
Benzo(a)pyrene	Fluoranthene
Fluorene	Carbazole
Pyrene	Dibenzofuran

ii) PCBs and pesticides,

iii) Trace Metals, and

iv) Conventional pollution parameters.

A summary is provided in Table 6 showing the analyses performed and indicating the laboratories where the work was carried out. In the case of the trace organics analyses performed by CANVIRO, liquid samples were extracted within one week of the sampling day. The storage period for dry solids prior to extraction was approximately three weeks. Prolonged storage of extracts prior to clean-up and GC analysis was avoided as much as possible.

2.2.4.2 Trace Organics - PAH Group

Eight base-neutral, semi-volatile trace organics were determined in the sample solid and liquid fractions. In Phase 1, two additional compounds; i.e. 1,4-dichlorobenzene and 2,6-dinitrotoluene were also included in the original list of selected compounds for extraction and analysis. As part of the Phase 1 program, some clean-up experiments were performed to determine whether these compounds could be adequately recovered using the established procedures already in use at CANVIRO (CANVIRO 1984). The experiments and the results obtained are described in Appendix A.

A summary of the analytical methods used throughout the experimental program is given in Figure 3. Only equipment made of recommended materials (e.g. glass, stainless steel and teflon) were used. To avoid the risk of contamination, plastic materials other than teflon were completely avoided.

All glassware and other equipment was prepared for use by soaking for several hours in detergent solution (Contrad 70), thorough rinsing in tap and distilled water, followed by overnight drying in an oven at 150°C. The solvents used were "Distilled in Glass" grade, made by Caledon Laboratories;

TABLE 6. SUMMARY OF CHEMICAL ANALYSES PERFORMED ON VARIOUS SAMPLE FRACTIONS

TRACE ORGANICS	TRACE METALS	CONVENTIONAL POLLUTION PARAMETERS
LABORATORY - CANVIRO	LABORATORY - MOE	LABORATORY - MOE
Sample Fractions Liquid Centrate Solids Analysis Acenaphthylene Benzo(a)pyrene Fluorene Fluoranthene Naphthalene Pyrene Carbazole Dibenzofuran	Sample Fractions Liquid Centrate Solids Analysis Aluminum (Al) Arsenic (As) Calcium (Ca) Cadmium (Cd) Colbalt (Co) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Mercury (Hg) Magnesium (Mg) Molybdenum (Mo) Nickel (Ni) Selenium (Se) Zinc (Zn)	Sample Fractions Uncentrifuged Liquid Analysis Turbidity Colour Suspended Solids Volatile Suspended Solids Biological Oxygen Demand (BOD_5) Chemical Oxygen Demand Dissolved Organic Carbon Dissolved Inorganic Carbon Total Particulate Carbon Unfiltered Total Kjeldahl Nitrogen Filtered Ammonia Nitrogen Filtered Nitrate Nitrogen Filtered Nitrite Nitrogen Total Phosphorus Filtered Phosphate
LABORATORY - MOE		
Sample Fractions Liquid Centrate Solids Analysis PCBs Pesticides		Sample Fractions Liquid Centrate Analysis Total Phenols

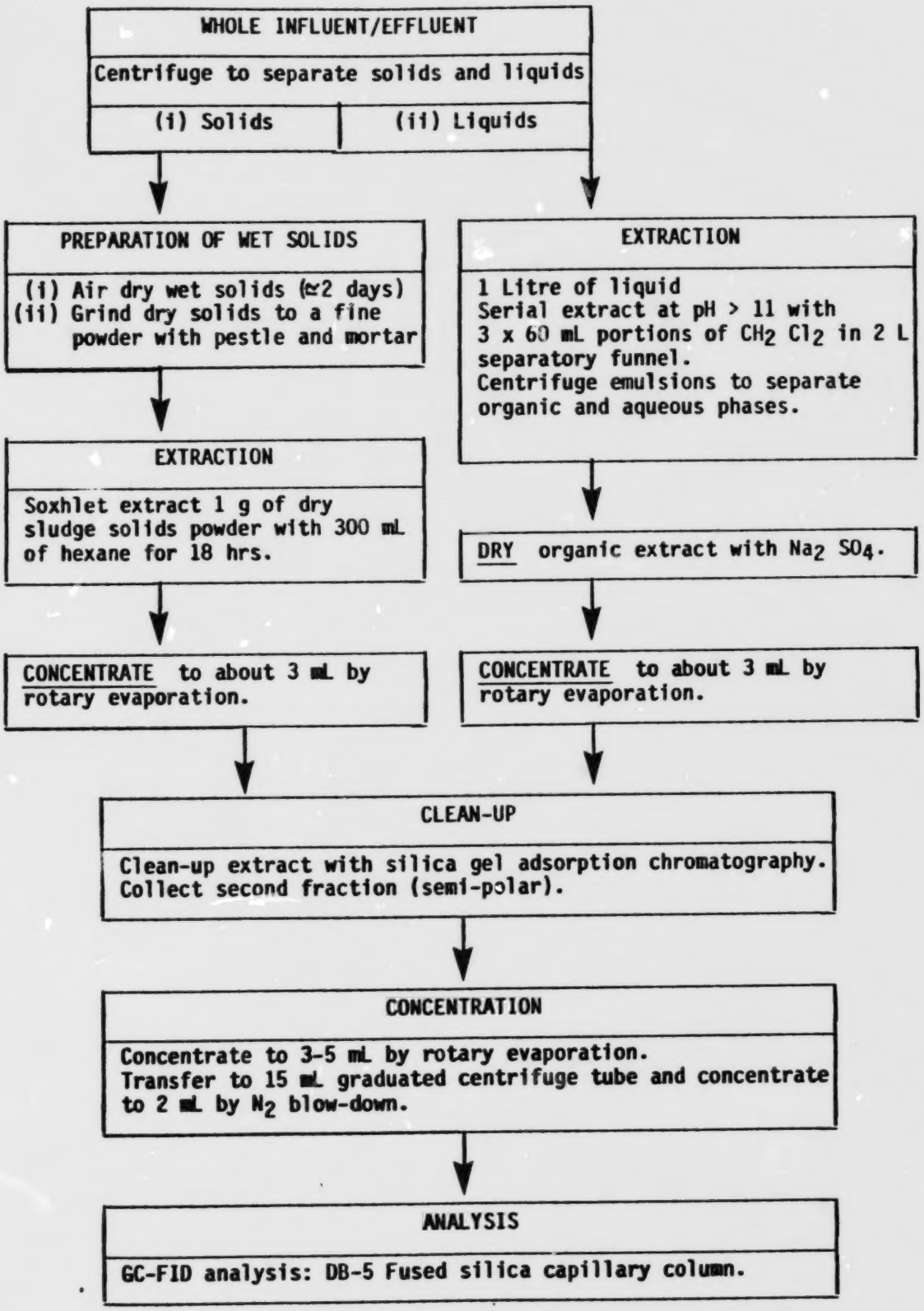

WHOLE INFLUENT/EFFLUENT
Centrifuge to separate solids and liquids
(i) Solids
(ii) Liquids
PREPARATION OF WET SOLIDS
(i) Air dry wet solids (≈2 days)
(ii) Grind dry solids to a fine powder with pestle and mortar
EXTRACTION
Soxhlet extract 1 g of dry sludge solids powder with 300 mL of hexane for 18 hrs.
CONCENTRATE to about 3 mL by rotary evaporation.
EXTRACTION
1 Litre of liquid
Serial extract at pH > 11 with 3 x 60 mL portions of CH_2Cl_2 in 2 L separatory funnel.
Centrifuge emulsions to separate organic and aqueous phases.
DRY organic extract with Na_2SO_4.
CONCENTRATE to about 3 mL by rotary evaporation.
CLEAN-UP
Clean-up extract with silica gel adsorption chromatography.
Collect second fraction (semi-polar).
CONCENTRATION
Concentrate to 3-5 mL by rotary evaporation.
Transfer to 15 mL graduated centrifuge tube and concentrate to 2 mL by N_2 blow-down.
ANALYSIS
GC-FID analysis: DB-5 Fused silica capillary column.

FIGURE 3 - SUMMARY OF THE ANALYTICAL METHODS FOR SELECTED TRACE ORGANICS IN SAMPLE SOLIDS AND LIQUIDS

solvent specifications were 99.8% pure, water content less than 0.2% and certified suitable for chromatographic analyses. Sample preparation was begun by centrifugation as described in Section 2.2.2. Separate extraction, clean-up and analysis were performed for each fraction.

Each wet solids sample was placed on a labelled watch glass and allowed to air dry for 2-3 days in a fumehood. When dry, the solids were finely ground using a pestle and mortar and then refrigerated in a 25 mL glass vial with a teflon lined septum screw cap. A 1 g portion of the prepared solids was soxhlet extracted in 300 mL of hexane for 18 hours. 1-2 mL iso-octane keeper was added to the cooled extract. The extract flask was closed with a ground glass stopper, sealed with teflon tape and refrigerated until required for clean-up.

Clean-up was performed using silica gel adsorption liquid chromatography as illustrated in Figure 4. A glass chromatography column (40 cms x 2 cms), was slurry packed with 3 percent deactivated silica gel (20 g 100-200 mesh), in dichloromethane. The column was prewashed with hexane (150 mL). The sample was concentrated to approximately 3 mL by rotary evaporation and then applied to the top of the prepared column. The column was eluted at a flow rate of 3 ± 1 mL per minute with hexane (90 mL) for Fraction 1 (F1) and 50 percent hexane in dichloromethane (90 mL) for Fraction 2 (F2). F1 was discarded and 1-2 mL of iso-octane keeper was added to F2, which was then concentrated to 3-5 mL by rotary evaporation. The concentrated F2 was transferred to a graduated centrifuge tube (15 mL), using a Pasteur pipette and 3 x 1 mL rinses of iso-octane. The extract was then concentrated to a final volume of 2 mL by nitrogen blow-down (ebullition) at 45-50°C. The centrifuge tube was closed with a ground glass stopper, sealed with teflon tape and refrigerated until analysis of the extract by GC-FID or GC-MS.

Extracts of liquids (1.0 L), were prepared by serial extraction with three portion (60 mL) of dichloromethane at pH >11 using a separatory funnel technique. Samples were hand shaken for two minutes after each solvent addition. A stable emulsion always formed after shaking and so each sample was allowed to settle under gravity for ten minutes. The emulsion, which had settled to the bottom of the separatory funnel was run-out into stainless steel centrifuge tubes (250 mL) and separated into organic and aqueous phases by centrifuging at 10,000 rpm for five minutes. Both phases were poured into a small separatory funnel (125 mL), and allowed to form two

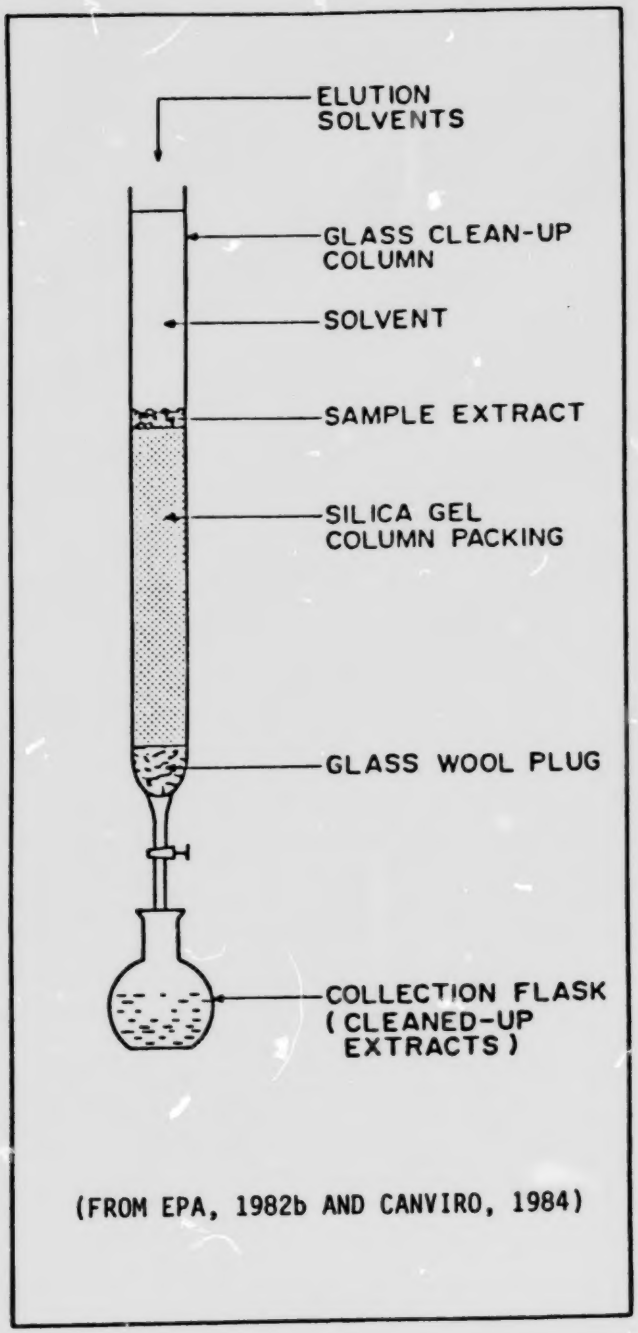


FIGURE 4 - SILICA GEL CLEAN-UP COLUMN SETUP

layers. The bottom organic layer was run-out into a drying column of sodium sulphate and then collected in a boiling flask. The aqueous phase remaining in a small separatory funnel was poured back into the bulk of the original sample before extraction with the next portion of solvent. Aliquots (10 mL) of dichloromethane were used to rinse the extract off the drying column and iso-octane keeper (1-2 mL) was added to the accumulated dried organic extract before refrigeration.

Just before clean-up, the extract was concentrated to 2-3 mL by rotary evaporation. Traces of dichloromethane from the extraction procedure were removed from the extract by adding it to a portion (2 g), of silica gel in a small beaker. The extract was dried onto the silica gel by constant stirring with a glass rod while very gently warming the beaker on a hot plate. In this manner, a dry and smooth-flowing powder was obtained. The clean-up column was setup as previously described and the sample was added to the top of the column in the form of the prepared powder. F2 was collected and concentrated to a final volume of 2 mL. The extract was refrigerated at 4°C until analysis by GC-FID and GC-MS.

Total solids analysis was performed on each sample of dry solids on the same day as soxhlet extraction. This data was used to convert the concentration of organic compounds in the solids to a dry weight basis.

Extracts were analyzed by capillary GC-FID using a DB-5 fused silica capillary column (15 meters x 0.25 mm I.D. with 0.25 um film thickness), and a Varian 3700 GC equipped with a auto sampler. Chromatograms and analytical reports were obtained on a Spectra-Physics computing integrator, Model SP4100. Compound identification was based on coincident retention times and peak areas obtained from analysis of a standard calibration solution (50 ng/uL) of each component. Daily analysis of the standard solution was used to provide confirmation of satisfactory instrument and column performance prior to the analysis of sample extracts. The equipment performance was considered satisfactory, provided that standard concentrations were reported as 50 ± 5 ng/uL. Contamination of the system caused the formation of active adsorption sites, which resulted in tailing peaks and reported standard concentrations below the required range. These effects were used as indicators to determine when injector hardware and analytical column required servicing.

Confirmatory analyses by GC-MS were also performed on representative extracts of each sample type (i.e. influent, effluent and in-plant return) and each sample fraction (i.e. solid and liquid).

In Phase 1, these analyses were performed at the Wastewater Technology Centre in Burlington using a Finnigan 1020 GC-MS system equipped with a DB-5 fused silica capillary column.

During Phase 2, these analyses were performed by MOE using a Finnigan 4500 GC-MS system equipped with a DB-1 fused silica capillary column.

2.2.4.3 Trace Organics - PCB, Pesticide and Chlorinated Phenolic Group

The compounds determined in this group are listed in Table 7. Wet solid and liquid centrate fractions were submitted to MOE for extraction and analysis of these trace organics. Standard MOE procedures of solvent extraction, clean-up and concentration were used. Analysis of the concentrated extracts was performed by GC-ECD.

2.2.4.4 Trace Metals

Wet solid and liquid centrate fractions were submitted to MOE for digestion and analysis of trace metals. Except for arsenic, selenium and mercury determinations, samples were acid digested and then analyzed by Inductively Coupled Argon Plasma (ICAP). Arsenic and selenium were determined by the hydride generation Atomic Absorption (AA) method and mercury was determined by the mercury cold vapour AA technique.

2.2.4.5 Conventional Pollution Parameters

Uncentrifuged influent, effluent and in-plant return samples were submitted to MOE for analysis. Standard MOE procedures were used.

2.2.5 Detection Limits

2.2.5.1 Trace Organics

Method detection limits are dependent on a variety of factors including, the characteristics of the sample, the chemical compound and the analytical method. Sample matrix interferences are often responsible for

TABLE 7. TYPICAL DETECTION LIMITS FOR PESTICIDES AND PCBs

COMPOUND	DETECTION LIMIT	
	SOLID FRACTION (ng/g)	LIQUID FRACTION (ng/L)
Aldrin	1	1
Alpha - BHC	1	1
Beta - BHC	1	1
Gamma - BHC	1	1
Alpha-Chlordane	2	2
Gamma-Chlordane	2	2
Dieldrin	2	2
DMDT Methoxychlor	5	5
Alpha-Endosulfan	2	2
Beta-Endosulfan	4	4
Endosulfan Sulphate	4	4
Endrin	4	4
Heptachlorepoxide	1	1
Heptachlor	1	1
Mirex	5	5
Oxychlordane	2	2
4,4-DDD	5	5
4,4-DDE	20	20
2,4-DDT	5	5
4,4-DDT	1	1
PCB, Total	5	5
Hexachlorobenzene	1	1
2,3,4-Trichlorophenol	100	100
2,4,5-Trichlorophenol	50	50
2,4,6-Trichlorophenol	50	50
2,3,4,5-Tetrachlorophenol	50	50
2,3,5,6-Tetrachlorophenol	50	50
Pentachlorophenol	50	50

are co-extracted from the sample but are not of interest. In municipal wastewaters, such components include saturated hydrocarbons and high molecular weight compounds, such as waxes, fatty acids and triglycerides. In GC analysis, such compounds typically cause sloping baselines spiked with a large number of unwanted peaks. Both qualitative and quantitative analysis tend to be less reliable under these conditions and the detection limits are raised accordingly.

During the course of this study, extracts of the influent solid fraction generated chromatograms with the worst baselines. Typically, the detection limit for the PAH group in extracts of the various solid fractions was 1 ug/g. In the case of the liquid fractions, the detection limit was 1 ug/L.

Typical detection limits reported by MOE for pesticides and PCBs are provided in Table 8.

TABLE 8. TYPICAL DETECTION LIMITS FOR METALS

METAL	DETECTION LIMIT		
	SEWAGE (mg/L)	SLUDGE (mg/L)	SOIL AND SEDIMENT (ug/g)
Aluminum	0.08	0.4	10
Arsenic	0.001	0.025	0.025
Calcium	0.05	5.0	10
Cadmium	0.03	0.3	0.3
Cobalt	0.04	0.5	0.3
Chromium	0.02	0.25	3.0
Copper	0.05	0.25	1.0
Iron	0.20	1.0	10.0
Lead	0.10	0.10	3.0
Mercury	0.00004	0.010	0.01
Magnesium	0.1	0.5	1.0
Molybdenum	0.05	0.25	2.0
Nickel	0.05	0.25	3.0
Selenium	0.001	0.025	0.025
Zinc	0.05	0.25	1.0

2.2.5.2 Trace Metals

Detection limit is defined as the concentration that produces absorption (or emission in ICAP), equivalent to twice the magnitude of the background fluctuation (i.e. noise). Detection limits depend on the element, the type of sample and the analytical technique used. A sample with a complex matrix, such as sludge, tends to cause more interference problems and a higher level of background noise than a relatively clean sample, such as water. Therefore, detection limits for the solid fractions were increased accordingly.

In this study, most metal concentrations in the solid fractions were above the detection limits of the methods used. Whereas, in the liquid fractions, some metal concentrations were at or below the detection limits.

MOE reported variable detection limits for most metals during the course of the study and therefore a summary of typical values is provided in Table 8 (MOE 1981).

2.2.5.3 Conventional Pollution Parameters

Detection limits reported by MOE for conventional parameters are listed in Table 9. In the case of the analyses not listed, the detection limits can be adjusted by changing the sample size or reagent concentrations. Therefore, the term detection limit does not have any meaningful application for these tests.

TABLE 9. TYPICAL DETECTION LIMITS FOR CONVENTIONAL POLLUTION PARAMETERS

ANALYSIS	DETECTION LIMIT IN SEWAGE
BOD	3 mg/L Oxygen
COD	11 mg/L Oxygen
Phenolics	1 ug/L
Phosphorus (Total)	0.04 mg/L as Phosphorus
Phosphorus (Filtered)	0.1 mg/L as Phosphorus
TKN	1 mg/L as Nitrogen
Ammonia	0.4 mg/L as Nitrogen
Nitrate	0.2 mg/L as Nitrogen

2.2.6 Quality Assurance/Quality Control

Quality Assurance (QA) is the total program for assuring the reliability of analytical data. Quality Control (QC) is the routine application of procedures for controlling the measurement process. Holtzclaw and Neptune (1980) have stated that the application of adequate quality control techniques, recognizes the sources of error in analysis, attempts to control them as far as possible, and estimates the residual variance that remains.

In this study, the principal aspects of QA/QC included:

a) Selection of suitable equipment and materials;
b) Proper preparation of the equipment prior to sampling and analysis;
c) Adequate preparation of the laboratory work area for convenience and cleanliness;
d) Continuous monitoring for background contamination by analysis of sample blanks;
e) Determination of precision by the analysis of duplicate samples; and
f) Determination of accuracy by:
   i) Analysis of spiked samples.
   ii) Confirmatory GC-MS analyses for the PAH trace organic group.

Descriptions of equipment, material types and preparation have been given in Sections 2.2.2 to 2.2.4.

Since the PAH trace organic group was the primary focus of the study, the analytical component of the QA/QC effort was concentrated on this group of contaminants.

Therefore during Phase 1, 24 hour composite samples were collected from the WPCP on two separate occasions so that a careful assessment of the analytical method and the associated precision and accuracy could be made. To this end, influent and effluent solid and liquid fractions were extracted and analyzed in triplicate for both sampling days. In addition, duplicate samples of each type were spiked at two concentrations in order to determine the recovery of the compounds. Spiking concentrations were:

50 and 100 ug/g for the solids fraction, and
50 and 100 ug/L for the liquid fraction.

Solids fractions were spiked by adding the spike solution to each sample (1 gram) in a small glass beaker (25 mL). Spiking compounds were allowed to air dry onto the sample matrix overnight in a fumehood. The sample was then carefully transferred to the soxhlet extraction thimble. At least three aliquots of solvent were used to rinse out the beaker and these rinses were added to the soxhlet flask. Then sample extraction was performed in the normal way.

Liquid samples were spiked by adding the spike solution directly into the sample in the separatory funnel just prior to extraction.

During Phase 2, duplicate and spiked samples of solid and liquid fractions of influent, effluent and in-plant return samples were extracted and analyzed routinely.

Duplicates and spiked samples comprised 16% and 21%, respectively, of the total samples analysed for PAHs during Phase 2. In addition, blanks and fortified blanks were also extracted and analyzed along side samples for each sampling occasion throughout the study.

During this phase, the spiking cocktail was added to the solid fractions in a manner different from the one used during Phase 1; i.e. instead of drying the spike solution onto the sample, the solution was added to the sample in the soxhlet apparatus just before beginning the extraction.

Confirmatory GC-MS analyses were also performed on representative extracts of each sample type during both phases. In Phase 2, these analyses were 18% of the total samples analysed for PAHs.

Those analyses performed by MOE (i.e. pesticides, PCBs, metals and conventional parameters) were subject to the routine QA/QC procedures performed by MOE laboratories. These are briefly summarized in Table 10 below.

TABLE 10. SUMMARY OF QA/QC PERFORMED FOR ANALYSES OF PESTICIDES, PCBs, METALS AND CONVENTIONAL PARAMETERS

PESTICIDES AND PCBs	METALS	CONVENTIONALS
For an analytical run of 12 samples the following was included: (i) 1 reagent blank (ii) 1 spiked standard matrix e.g. dried sewage sludge or sediment (iii) 1 duplicate sample	For an analytical run of 40 samples the following was included: (i) 2 reagent blanks (ii) 2 samples of a standard matrix spiked at 2 concentrations (iii) 2 duplicates	Typical analytical runs involve 100-200 samples. Reagent blanks, standards and duplicates were distributed evenly throughout the run for each parameter.

3.0 RESULTS AND DISCUSSION

3.1 Introduction

The analytical results for Phase 1 and Phase 2 have been compiled in tabular form and are presented in Appendices A and B.

Appendix A describes the extraction and clean-up experiments performed to determine the feasibility of including 1,4-dichlorobenzene and 2,6-dinitrotoluene in Phase 2 of the study. Considerable additional work would have been required in order to optimize the clean-up procedure for these compounds without jeopardizing the recoveries of the PAH group. Unfortunately, scheduling restrictions precluded the possibility of improving the method further, and hence, these compounds were not included among the contaminants monitored at the WPCP.

Appendix B contains tabulated raw analytical results for Phase 1 (PAH group only) and Phase 2 (PAH group, PCBs, pesticides, metals and conventionals). Since the PAH group was the primary focus of the study, a QA/QC result summary and discussion of analytical precision and compound recoveries for this group is also included in Appendix B.

The remainder of the report focuses on the treatment plant removal efficiency and has been organized into three separate sections.

The first (Section 3.2) is a review of the Hamilton WPCP monitoring data which provides an indication of whether or not the plant was functioning in typical operating ranges during the study period.

The second area of discussion focuses on the plant's treatment efficiency with respect to hazardous contaminants (Section 3.3). This section also provides an estimate of the loadings of priority pollutants entering and being discharged from the Hamilton facility.

In the third section (Section 3.4), effects of process operations such as solids retention time and in-plant returns as well as miscellaneous factors such as seasonal differences were assessed to determine their relative impacts on treatment efficiency.

3.2 Review of Treatment Plant Routine Monitoring Data During the Study Period

3.2.1 General

In order to provide background on the treatment plant operation and performance during the study period, all the routine monitoring records from the facility were reviewed and summarized. Analysis of these records for variability and comparison to plant design parameters allowed a determination of whether or not the system was functioning typically during the study period, and specifically, on the days when samples were collected.

3.2.2 Operating Conditions

A summary log of major operational events at the treatment plant during the study period is presented in Table 11. Although a relatively small number of major operational events were identified during the study, some notable observations did result. During the early part of the program, December to mid-January, the plant operated utilizing only four of the eight aeration basins available in the old secondary treatment section.

After mid-January, the facility employed five of the old basins until a sixth was brought on-line in mid-March.

The initial two months, December and January, produced only five miscellaneous events, most notable of which was the discontinuation of sludge wasting from the old section of the plant during the week of January 17.

During the month of April, the primary clarifiers were substantially overloaded for a period of two weeks. During the summer season, May to mid-August, no operational events were identified which appreciably effected the plant's performance.

Tables 12 and 13 provide summaries of the average plant operating conditions on a monthly and sampling day basis, respectively. Analysis of the summaries indicated that on average, the daily flow rates were below the design value of 408,420 m^3/d; however, isolated daily peaks were typically in excess of 430,000 m^3/d.

TABLE 11. SUMMARY LOG OF MAJOR OPERATIONAL EVENTS AT THE TREATMENT PLANT DURING THE STUDY PERIOD

	1982 NOV 29-DEC 05	DEC 06-DEC 12	DEC 13-DEC 19	DEC 20-DEC 26	DEC 27-	JAN 03-JAN 09	JAN 10-JAN 16	JAN 17-JAN 23	JAN 24-JAN 30	JAN 31-FEB 06
Influent/ Primaries				-Bar screen down for motor repair						
Aeration/ Secondaries	4 basins I/S	4 basins I/S	-Aeration basin emp-emptied -Completed on Dec. 15 -Level in return line was halfway up to cat-walk 4 basins I/S	4 basins I/S	4 basins I/S	4 basins I/S	-Added 3rd cell to new plant 5 basins I/S	-WAS off on old plant throughout week (wasting resumed on Jan. 25) -WAS used to melt down frozen clar-clarifier Jan. 18 5 basins I/S	-#4 final clarifier gate won't shut properly so MLSS to drain Jan. 25 (required) next day -filling Row D from Row C -Row C remains dumped on Jan. 26 5 basins I/S	5 basins I/S
Digesters	-Dec. 8 started to clean out Digester #2	-≃Dec. 12 clean out process was aborted because proper equipment was not available								
Filter/ Incinerators										

TABLE 11 (CONT'D). SUMMARY LOG OF MAJOR OPERATIONAL EVENTS AT THE TREATMENT PLANT DURING THE STUDY PERIOD

	1983 FEB 07-FEB 13	FEB 14-FEB 20	FEB 21-FEB 27	FEB 28-MAR 06	MAR 07-MAR 13	MAR 14-MAR 20	MAR 21-MAR 27	MAR 28-APR 03	APR 04-APR 10	APR 11-APR 17
Influent/ Primaries					-March 8-June 1 higher than normal, solids in primary effluent 150-250 mg/L usually 60-85 mg/L					
Aeration/ Secondaries	5 basins I/S	5 basins I/S	-Feb. 24 RAS cutback from 30 mgd to 18 mgd 5 basins I/S	5 basins I/S	5 basins I/S	-Added 2 rows aeration to old plant 16th 7 basins I/S	-March 23 shutdown 1 cell on new plant 6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S
Digesters										
Filter/ Incinerators								-March 28 water from ash lagoon returned to plant rather than Red Hill Creek -Continued throughout remainder of study	-Filter #2 out of service April 1 -Filter #1 out of service April 13	

TABLE 11 (CONT'D). SUMMARY LOG OF MAJOR OPERATIONAL EVENTS AT THE TREATMENT PLANT DURING THE STUDY PERIOD

	1983 APR 18-APR 24	APR 25-MAY 01	MAY 02-MAY 08	MAY 09-MAY 15	MAY 16-MAY 22	MAY 23-MAY 29	MAY 30-JUN 05	JUN 06-JUN 12	JUN 13-JUN 19	JUN 20-JUN 26
Influent/ Primaries	-Primaries overloaded especially west side	-Primaries overloaded west side -Combined effluent was black April 27								-Primary clarifier overloaded not as noticeable as previous
Aeration/ Secondaries	-April 19 new plant shut-down for 8 hours for maintenance 6 basins I/S	6 basins I/S	-Old plant Row B aerators broke down -Transferred to Row A May 5 6 basins I/S	-May 15 chlorination begins 6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S
Digesters										
Filter/ Incinerators	-Filters #1 & #2 dismantled -Filter presses to replace them. Came on-line in October									

TABLE 11 (CONT'D). SUMMARY LOG OF MAJOR OPERATIONAL EVENTS AT THE TREATMENT PLANT DURING THE STUDY PERIOD

	1983 JUN 27-JUL 03	JUL 04-JUL 10	JUL 11-JUL 17	JUL 18-JUL 24	JUL 25-JUL 31	AUG 01-AUG 07	AUG 08-AUG 14
Influent/ Primaries			-July 12 excessive foaming of primary effluent			-August 3 excessive foaming of primary effluent -High SS from primary clarifier during first part of week due to heavy rains	
Aeration/ Secondaries	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	6 basins I/S	-August 8 screw conveyor belt broken so new plant shutdown for ≃ 2 hours 6 basins I/S
Digesters							
Filter/ Incinerators							

TABLE 12. SUMMARY OF AVERAGE MONTHLY PLANT OPERATING CONDITIONS DURING THE STUDY PERIOD

	DAILY FLOW RATE		PRIMARY CLARIFIER HYDRAULIC LOADING		AVERAGE AERATION SYSTEM OPERATING CONDITIONS					SECONDARY CLARIFIERS HYDRAULIC LOADING			
	AVG. DAY (m^3/d)	PEAK DAY (m^3/d)	AVG. DAY ($m^3/m^2.d$)	PEAK DAY ($m^3/m^2.d$)	HRT (h)	MLVSS (mg/L)	BOD LOADING ($g/m^3.h$)	F/M	SRT (days)	NEW SECTION AVG. FLOW (m^3/d)	NEW SECTION AVG. HYDRAULIC LOADING ($m^3/m^2.d$)	OLD SECTION AVG. FLOW (m^3/d)	OLD SECTION AVG. HYDRAULIC LOADING ($m^3/m^2.d$)
DECEMBER	312310	433234	41.0	56.9	2.06	1900	33.0	0.41	3.57	58,643	11.0	253,666	48.9
JANUARY	264577	545520	34.7	71.6	2.69	1753	27.2	0.36	8.1	49,552	9.3	215,026	33.1
FEBRUARY	286261	445508	37.6	58.5	2.65	1924	27.0	0.34	4.7	131,379	24.6	154,564	23.8
WINTER AVERAGE	287716	474754	37.8	62.3	2.47	1859	29.1	0.37	5.4	79,858	15.0	207,752	35.3
MARCH	314129	472784	41.6	62.1	2.9	1900	26.1	0.33	2.9	104,331	19.5	150,473	26.9
APRIL	332767	604618	43.7	79.4	3.17	1608	14.2	0.27	6.3	85,465	16.0	246,848	31.7
MAY	318675	559158	41.8	73.4	3.36	1667	17.6	0.24	5.6	117,286	21.9	201,388	25.8
SPRING AVERAGE	321857	545520	42.4	71.6	3.14	1725	19.3	0.28	4.9	102,361	19.1	199,570	28.1
JUNE	288216	445508	37.8	58.5	3.65	1938	13.8	0.17	4.7	106,831	20.0	181,385	23.3
JULY	266850	545520	35.0	71.6	3.83	1320	7.3	0.13	6.5	93,193	17.4	173,202	22.2
AUGUST	285898	590980	37.5	77.6	3.75	1649	11.1	0.16	8.8	82,283	15.4	201,388	25.8
SUMMER AVERAGE	280321	527336	36.8	69.2	3.74	1636	10.7	0.15	6.7	94,102	17.6	185,325	23.8
OVERALL AVERAGE	296631	515870	39.0	67.7	3.12	1741	19.7	0.27	5.7	92,107	17.2	197,549	29.0
OVERALL MAXIMUM	332767	604618	43.7	79.4	3.83	1938	33.0	0.41	8.8	131,379	24.6	253,666	48.9
OVERALL MINIMUM	264577	433234	34.7	56.9	2.06	1320	7.3	0.13	2.9	49,552	9.3	150,473	22.2

TABLE 13. SUMMARY OF AVERAGE PLANT OPERATING CONDITIONS ON SAMPLING DAYS

SAMPLING DAY	SAMPLING DATES	AVERAGE FLOW (m^3/d)	PRIMARY CLARIFIER HYD. LOAD. RATE (m/d)	AVERAGE AERATION SYSTEM OPERATING CONDITIONS				
				HRT (h)	MLVSS (mg/L)	BOD LOADING ($g/m^3.h$)	F/M	INSTANTANEOUS SRT (days)
1	Dec. 6-7	330,000	43.3	1.99	2168	36.0	0.39	3.28
2	Dec. 20-21	274,000	36.0	2.37	2298	23.8	0.25	2.57
3	Jan. 5-6	266,000	34.9	2.45	1565	23.3	0.35	NA
4	Jan. 11-12	297,000	38.9	2.50	1535	35.7	0.53	7.5
5	Jan. 18-19	265,000	34.8	2.39	1600	40.4	0.60	6.21
6	Jan. 25-26	274,000	36.0	2.37	1911	33.1	0.41	10.52
WINTER AVERAGE		284,300	37.3	2.35	1846	32.0	0.42	6.02
7	Apr. 13-14	371,000	48.6	2.89	1602	39.9	0.34	1.48
8	Apr. 21-22	287,000	37.7	3.69	1624	19.0	0.28	1.48
9	Apr. 26-27	287,000	37.7	3.75	1608	23.2	0.34	1.48
10	May 2-3	384,000	50.4	2.76	1558	21.9	0.32	6.0
SPRING AVERAGE		321,500	43.6	3.27	1598	26.0	0.32	2.61
11	June 22-23	290,000	38.0	3.66	1672	11.6	0.16	5.27
12	July 11-12	270,000	35.5	3.91	1463	8.0	0.13	6.22
13	Aug. 2-3	277,000	36.3	3.82	1786	10.1	0.15	1.89
14	Aug. 8-9	289,000	38.0	3.66	1558	16.6	0.24	1.48
SUMMER AVERAGE		281,500	37.0	3.76	1620	11.6	0.17	3.72
OVERALL AVERAGE		297,000	39.0	3.0	1711	24.5	0.35	4.0
OVERALL MAXIMUM		384,000	50.4	3.91	2298	40.4	0.60	10.52
OVERALL MINIMUM		265,000	34.8	1.99	1463	8.0	0.13	1.48

As was found in the previous CANVIRO study (CANVIRO 1983), the primary clarifiers at the Hamilton plant are frequently overloaded. The design hydraulic loading level of 35.7 $m^3/m^2/d$ is less than the average values recorded for any of the three seasonal periods assessed during the study. This overloading problem can be expected to persist because the primary facilities were designed to handle an influent flow of only 272,780 m^3/d, which is consistently exceeded in terms of daily averages.

Unlike the primary section, the flow to the secondary treatment section is divided between two separate facilities. The original (old) facility contains 8 aeration tanks and 8 final clarifiers, while the new system is half the size, consisting of 4 aeration tanks and 4 final clarifiers.

There was little problem with overloading of the new section during the monitoring program since flows to that side of the plant (overall avg. = 95,200 m^3/d) were well below the design value of 136,140 m^3/d. However, due to the use of only 50% to 66% of the old system during periods of flow near the 272,280 m^3/d capacity, overloading in the old secondary treatment facilities was common. The worst period for hydraulic overloading was the winter period, during which only 4 of the original basins were receiving wastewater. However, at no time did the daily average flows to the old section exceed design capacity of the whole old section. Thus, the overloading problem could have been avoided had all 8 basins been functioning during the study.

The aeration system operating conditions given in Tables 12 and 13 represent a flow weighted average between the old system and new system values. This was done to provide a set of conditions which would represent the overall aeration system operation, thus allowing general comparisons to values found in other studies and recommended design guidelines.

The overall average HRT recorded for the system was 3.12 hours which is considerably below the plant's design HRT of 5.2 hours and the MOE guideline of 6 hours minimum for conventional activated sludge plants (MOE 1980).

The average SRT calculated (5.7 days) is within the range of 4-8 days suggested by the MOE for conventional activated sludge plants without nitrification (MOE 1980).

The remainder of the aeration system parameters (e.g. MLVSS, BOD loading, food to microorganism ratio) generally adhere to the suggested MOE

ranges for design of activated sludge plants (e.g. MLVSS = 1500-3000 mg/L, BOD loading 13-30 $g/m^3 \cdot h$, F/M = 0.2-0.5), although loadings were somewhat higher during the winter period because only part of the old section was being utilized during the study. The average loadings recorded for the secondary clarifiers reflect this problem of hydraulic overloads in the old section of the plant.

Both groups of secondary basins have the same design loading of 25.4 $m^3/m^2/d$. However, recorded values for the new side rarely exceeded this level, averaging 17.2 $m^3/m^2/d$, while the old section loading was consistently above design, averaging 29.0 $m^3/m^2/d$.

The effect of these plant design/operating parameters on hazardous contaminant removal efficiency is discussed in Section 3.4.3.1.

3.2.3 Performance Data

Tables 14 through 16 summarize the plant's performance as monitored by the Hamilton WPCP laboratory. Table 14 presents average monthly values for plant performance, Table 15 gives plant performance for a week prior to the sampling dates and Table 16 provides sampling results on the study days. A summary comparison of the results for SS, BOD_5 and phosphorus is presented in Table 17 to demonstrate that the performance characteristics of the plant on, and immediately prior to, the sampling days were within the range of typical values for the year.

Influent and effluent concentrations of suspended solids on, and one week prior to, the sampling day were generally in good agreement with monthly averages. One exception was noted on January 25 when an influent suspended solids concentration of 12,079 mg/L was recorded, which is 40 times the overall monthly average of 299 mg/L. This was an isolated result with no apparent correlation to excessive values in the other parameters; thus, the value was not included in the mean.

There was a general trend towards higher influent suspended solids concentrations and associated higher effluent suspended solids concentrations during the winter season. Although the actual concentrations were seasonally affected, the resulting removal rates remained relatively unchanged.

Tables 14 and 16 show that the majority of suspended solids removal was achieved in the primary clarifiers (on a mass basis).

TABLE 14. SUMMARY OF AVERAGE MONTHLY PLANT PERFORMANCE MONITORING DATA DURING THE STUDY PERIOD

DATE	PARAMETER	COMBINED INFLUENT (mg/L)			PRIMARY EFFLUENT (mg/L)			PERCENT REMOVAL IN PRIMARY CLARIFIERS	FINAL EFFLUENT (mg/L)			PERCENT REMOVAL IN AERATION SECTION	OVERALL PERCENT REMOVAL
		(mg/L) AVERAGE	(mg/L) MAX.	(mg/L) MIN.	AVERAGE	MAX.	MIN.		AVERAGE	MAX.	MIN.		
Dec. 1982	Suspended Solids	266	748	108	112	243	64	58	18	57	6	84	93
Jan. 1983		641	12079	75	108	174	68	83	14	24	6	87	98
Feb. 1983		256	373	133	94	144	65	63	17	24	11	82	93
WINTER AVG.		388	4400(a)	105	105	187	66	68	16	35	8	84	95
Mar. 1983		259	320	140	119	260	67	54	15	27	7	87	94
Apr. 1983		260	445	168	105	229	73	60	9	22	4	91	97
May 1983		266	636	149	112	218	67	58	11	87	4	90	96
SPRING AVG.		262	534	457	112	236	69	57	12	45	5	89	96
June 1983		269	495	188	95	265	58	65	11	23	6	88	96
July 1983		229	356	108	58	87	36	75	8	15	5	86	97
Aug. 1983		243	324	148	70	150	35	71	13	99	2	81	95
SUMMER AVG.		247	392	148	74	167	43	70.3	11	46	4	85	96
Overall	Average	299			97			65	13			86	96
	Maximum	641			119			83	18			91	98
	Minimum	229			58			54	8			81	93
Dec. 1982	Total BOD_5	134	234	18	67.7	177.0	14.0	49	11	25	4	84	92
Jan. 1983		151	341	50	72.5	119.0	24.0	52	12	23	3	83	92
Feb. 1983		152	207	79	71.7	128.0	46.0	53	12	19	1	83	92
WINTER AVG.		146	281	49	71	141	28	51	12	22	3	83	92
Mar. 1983		122	229	64	73.0	119.0	45.0	40	10	20	4	86	92
Apr. 1983		119	186	67	57.7	88.0	30.0	52	6	15	2	90	95
May 1983		110	160	52	57.8	114.0	25.0	47	7	41	0	88	94
SPRING AVG.		117	192	61	63	107	33	46	8	25	2	88	94
June 1983		129	189	61	50.2	94.0	26.0	61	12	22	4	76	91
July 1983		118	162	25	29.1	53.0	0.0	75	10	17	2	66	92
Aug. 1983		115	191	46	46.3	95.0	20.0	60	17	50	4	63	85
SUMMER AVG.		121	181	44	42	81	15	65	13	30	3	68	89
Overall	Average	128			58.4			54	11			80	92
	Maximum	152			73.0			75	17			90	95
	Minimum	110			29.1			40	6			63	85
Dec. 1982	Total Phosporus	6.0	13.0	1.9	NA	NA	NA	NA	1.2	4.2	0.4	NA	80
Jan. 1983		5.9	9.3	2.8					1.2	2.3	0.5		80
Feb. 1983		6.1	8.3	4.3					1.0	2.5	0.4		84
WINTER AVG.		6.0	10.2	3.0	NA	NA	NA	NA	1.1	3.0	0.4	NA	81
Mar. 1983		5.7	8.0	3.7	NA	NA	NA	NA	0.7	1.8	0.3	NA	88
Apr. 1983		6.1	8.5	3.6					0.8	1.1	0.3		87
May 1983		6.3	8.7	4.0					1.2	2.9	0.5		81
SPRING AVG.		6.0	8.4	3.8	NA	NA	NA	NA	0.9	1.9	0.4	NA	85
June 1983		7.3	12.5	4.3	NA	NA	NA	NA	1.4	2.2	0.6	NA	81
July 1983		6.8	9.6	3.9					1.3	3.2	0.5		81
Aug. 1983		6.3	9.9	4.0					1.1	3.4	0.3		83
SUMMER AVG.		6.8	10.7	4.1	NA	NA	NA	NA	1.27	2.9	0.5	NA	82
OVERALL	Average	6.3			NA			NA	1.1			NA	83
	Maximum	7.3							1.4				88
	Minimum	5.7							0.7				80
Dec. 1982	NH_3 - N	NA	NA	NA	(*) 28 (4)	31	22	NA	(*) 28 (4)	31	22	0	NA
Jan. 1983					36 (2)	37	35		35 (2)	37	32	3	
Feb. 1983					37 (3)	50	26		33 (2)	37	30	11	
WINTER AVG.		NA	NA	NA	34	39	28	NA	32	35	28	5	NA
Mar. 1983		NA	NA	NA	29 (3)	32	27	NA	31 (3)	32	30	-7+	NA
Apr. 1983					25 (2)	34	15		28 (2)	34	22	-8	
May 1983					16 (1)	16	16		19 (1)	19	19	-19	
SPRING AVG.		NA	NA	NA	23	27	19	NA	26	28	24	-11+	NA
June 1983		NA	NA	NA	30 (1)	30	30	NA	26 (1)	26	26	13	NA
July 1983					21 (2)	22	21		19 (2)	27	11	10	
Aug. 1983					28 (4)	41	16		19 (4)	32	8	32	
SUMMER AVG.		NA	NA	NA	26	31	22	NA	21	28	15	18	NA
OVERALL	Average	NA	NA	NA	28			NA	26			4	NA
	Maximum				37				35			32	
	Minimum				16				19			-19+	

Notes: (*) = Number of analysis performed per month
(a) - When Max. = 12079 is eliminated, Average = 561 instead of 4400 mg/L.

Data confirmed by laboratory but questionable.

TABLE 15. GENERAL CHARACTERISTICS OF COMBINED INFLUENT AND FINAL EFFLUENT DURING 1 WEEK PRECEDING EACH SAMPLING DATE

PHASE 2 SAMPLING DAYS	SAMPLING DATES & DATES PRECEDING	SUSPENDED SOLIDS			TOTAL PHOSPHORUS			TOTAL BOD_5		
		COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)
#1	Dec 1/82	206	8	96	6.3	0.9	86	126	11	91
	2	272	9	97	6.4	0.8	88	133	10	92
	3	260	6	98	6.0	0.7	88	169	9	95
	4	195	23	88	4.7	1.0	79	110	7	94
	5	333	8	98	4.9	0.5	90	123	13	89
	* 6	748	43	94	8.2	1.7	79	194	23	88
	* 7	175	16	91	5.2	1.5	71	107	12	89
	Average	253	11	95	5.7	0.8	86	132	10	92
	Maximum	333	23	98	6.4	1.0	90	169	13	95
	Minimum	195	6	88	4.7	0.5	79	110	7	89
#2	Dec 14/82	378	11	97	9.5	2.2	77	189	10	95
	15	299	32	89	6.5	4.2	35	212	18	92
	16	338	18	95	5.3	2.1	60	171	25	85
	17	265	14	95	6.2	0.8	87	132	14	89
	18	231	15	94	6.5	1.2	82	117	14	88
	19	217	12	94	5.2	0.4	92	96	5	95
	* 20	208	17	92	5.1	0.5	90	111	13	88
	* 21	256	19	93	5.8	1.1	81	153	16	90
	Average	288	17	94	6.5	1.8	72	153	13	91
	Maximum	378	32	97	9.5	4.2	92	212	25	95
	Minimum	217	11	89	5.2	0.4	35	96	5	85
#3	Dec 30/82	130	16	88	3.9	1.8	54	110	6	95
	31	108	12	89	3.4	1.5	56	50	8	84
	Jan 1/83	75	7	91	2.8	1.4	50	50	20	60
	2	156	9	94	5.3	1.9	64	93	3	97
	3	240	10	96	6.4	2.3	64	132	8	94
	4	247	12	95	5.8	2.2	62	128	9	93
	* 5	731	18	99	9.3	1.9	80	145	12	92
	* 6	188	20	89	6.4	1.9	70	180	13	93
	Average	153	11	92	4.6	1.7	48	71	8	87
	Maximum	247	16	96	6.4	2.3	64	132	20	97
	Minimum	75	7	88	2.8	1.4	50	50	3	60

* indicates sampling day

TABLE 15 (CONT'D). GENERAL CHARACTERISTICS OF COMBINED INFLUENT AND FINAL EFFLUENT DURING 1 WEEK PRECEDING EACH SAMPLING DATE - CONTINUED

PHASE 2 SAMPLING DAYS	SAMPLING DATES & DATES PRECEDING	SUSPENDED SOLIDS			TOTAL PHOSPHORUS			TOTAL BOD_5		
		COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)
#4	Jan 5/83	731	18	98	9.3	1.9	80	145	12	92
	6	188	20	89	6.4	1.9	70	180	13	93
	7	307	19	94	6.2	1.6	74	108	21	81
	8	226	18	92	5.1	1.7	67	184	21	89
	9	258	16	94	4.8	1.0	79	138	18	87
	10	314	15	95	5.8	1.3	78	214	6	97
	* 11	248	24	90	5.2	1.1	79	133	14	89
	* 12	259	20	92	4.9	1.0	80	127	13	90
	Average	337	18	94	5.4	1.6	75	144	15	90
	Maximum	731	20	98	9.3	1.9	80	214	21	97
	Minimum	188	15	89	4.8	1.0	67	108	6	81
#5	Jan 12/83	259	20	92	4.9	1.0	80	127	13	90
	13	266	20	92	5.8	1.3	78	147	16	89
	14	277	16	94	5.8	1.1	81	199	14	93
	15	236	12	95	6.4	0.9	86	136	12	91
	16	219	13	94	6.2	0.8	87	163	15	91
	17	278	12	96	6.6	1.2	82	138	7	95
	* 18	228	19	92	5.8	1.4	76	133	9	93
	* 19	379	19	95	8.2	1.3	84	144	11	92
	Average	256	16	94	6.0	1.1	82	151	13	92
	Maximum	278	20	96	6.6	1.3	87	199	16	95
	Minimum	219	12	92	4.9	0.8	78	127	7	89
#6	Jan 19/83	379	19	95	8.2	1.3	84	144	11	92
	20	219	18	92	5.5	1.0	82	144	10	93
	21	234	18	92	5.7	0.9	84	131	15	89
	22	223	13	94	5.8	1.0	84	129	13	90
	23	265	6	98	5.6	0.7	88	151	7	95
	24	223	8	96	5.6	1.0	82	131	6	95
	* 25	12079	13	99	6.6	1.4	79	341	7	98
	* 26	291	7	98	7.0	0.8	89	193	12	94
	Average	257	14	95	6.1	1.0	84	138	10	92
	Maximum	379	19	98	8.2	1.3	88	151	15	95
	Minimum	219	6	92	5.5	0.7	82	129	6	89

TABLE 15 (CONT'D). GENERAL CHARACTERISTICS OF COMBINED INFLUENT AND FINAL EFFLUENT DURING 1 WEEK PRECEDING EACH SAMPLING DATE - CONTINUED

PHASE 2 SAMPLING DAYS	SAMPLING DATES & DATES PRECEDING	SUSPENDED SOLIDS			TOTAL PHOSPHORUS			TOTAL BOD_5		
		COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)
#7	Apr 7/83	341	11	97	3.6	0.8	78	143	8	94
	8	303	10	97	8.2	0.7	91	155	6	96
	9	250	7	97	6.4	0.8	88	121	8	93
	10	264	14	95	4.5	0.8	82	85	9	89
	11	217	11	95	5.1	0.9	82	98	5	95
	12	194	9	95	5.1	1.1	78	79	4	89
	* 13	190	8	96	4.4	1.0	77	103	7	93
	* 14	178	9	95	4.2	0.7	83	88	7	92
	Average	262	10	96	5.5	0.9	83	114	7	93
	Maximum	341	14	97	8.2	1.1	91	155	9	96
	Minimum	194	7	95	3.6	0.7	78	79	4	89
#8	Apr 15/83	219	16	93	4.7	0.7	85	67	5	93
	16	201	9	96	5.9	0.7	88	100	8	92
	17	305	8	97	5.9	0.8	86	150	4	97
	18	217	10	95	5.9	0.8	86	119	4	97
	19	314	8	97	6.6	0.8	88	138	5	96
	20	277	7	97	6.4	0.8	88	149	7	95
	* 21	312	11	96	8.4	0.4	95	186	5	97
	* 22	246	5	98	6.9	0.3	96	120	3	98
	Average	256	10	96	6.0	0.8	87	121	6	95
	Maximum	314	16	97	6.6	0.8	88	150	8	97
	Minimum	201	7	93	4.7	0.7	85	67	4	92
#9	Apr 20/83	277	7	97	6.4	0.8	88	149	7	95
	21	312	11	96	8.4	0.4	95	186	5	97
	22	246	5	98	6.9	0.3	96	120	3	98
	23	192	5	97	5.3	0.3	94	130	2	98
	24	182	4	98	5.4	0.4	93	80	3	96
	25	168	5	97	5.8	0.5	91	97	4	96
	* 26	192	7	96	6.4	0.7	89	117	4	97
	* 27	320	5	98	6.3	0.9	86	119	6	95
	Average	230	6	97	6.4	0.5	93	127	4	97
	Maximum	312	11	98	8.4	0.8	96	186	7	98
	Minimum	168	4	96	5.3	0.3	88	80	2	95

TABLE 15 (CONT'D). GENERAL CHARACTERISTICS OF COMBINED INFLUENT AND FINAL EFFLUENT DURING 1 WEEK PRECEDING EACH SAMPLING DATE - CONTINUED

PHASE 2 SAMPLING DAYS	SAMPLING DATES & DATES PRECEDING	SUSPENDED SOLIDS			TOTAL PHOSPHORUS			TOTAL BOD_5		
		COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)
#10	Apr 26/83	192	7	96	6.4	0.7	89	117	4	97
	27	320	5	98	6.3	0.9	86	119	6	95
	28	270	6	98	6.6	0.9	86	111	4	96
	29	280	NA	NA	6.7	0.8	88	124	5	96
	30	243	22	91	4.9	1.1	78	94	15	84
	May 1	228	18	92	5.2	1.0	81	108	8	93
	* 2	199	9	95	4.1	0.7	83	94	11	88
	* 3	205	19	91	4.3	0.8	81	104	12	88
	Average	256	12	95	6.0	0.9	85	112	7	94
	Maximum	320	22	91	6.7	1.1	89	124	15	97
	Minimum	192	5	98	4.9	0.7	78	94	4	84
#11	Jun 16/83	270	11	96	8.5	2.0	76	130	10	92
	17	275	8	97	8.2	1.6	80	112	9	92
	18	241	8	97	6.5	1.2	82	113	9	92
	19	249	9	96	6.6	1.2	82	117	11	91
	20	204	11	95	6.9	2.1	70	133	17	87
	21	253	9	96	7.1	1.6	77	129	12	91
	* 22	250	11	96	6.5	1.1	83	121	14	88
	* 23	495	13	97	12.5	1.4	89	189	4	98
	Average	249	9	96	7.3	1.6	78	122	11	91
	Maximum	275	11	97	8.5	2.1	82	133	17	92
	Minimum	204	8	95	6.5	1.2	70	112	9	87
#12	Jul 5/83	293	9	97	6.4	1.1	83	142	13	91
	6	270	8	97	7.4	0.9	88	145	8	94
	7	270	8	97	7.7	0.9	88	156	9	94
	8	356	8	98	8.3	0.9	89	162	6	96
	9	160	5	97	6.8	0.8	88	141	16	89
	10	166	7	96	5.8	1.2	79	104	14	87
	* 11	225	7	97	5.9	1.6	73	137	8	94
	* 12	192	7	96	4.5	1.5	67	105	9	91
	Average	253	8	97	7.1	1.0	86	142	11	92
	Maximum	356	9	98	8.3	1.2	89	162	16	96
	Minimum	160	5	96	5.8	0.8	79	104	6	87

* indicates sampling day

TABLE 15 (CONT'D). GENERAL CHARACTERISTICS OF COMBINED INFLUENT AND FINAL EFFLUENT DURING 1 WEEK PRECEEDING EACH SAMPLING DATE - CONTINUED

PHASE 2 SAMPLING DAYS	SAMPLING DATES & DATES PRECEDING	SUSPENDED SOLIDS			TOTAL PHOSPHORUS			TOTAL BOD_5		
		COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)	COMBINED INFLUENT (mg/L)	FINAL EFFLUENT (mg/L)	REMOVAL (%)
#13	Jul 27/83	227	9	96	5.5	0.6	89	99	5	95
	28	194	11	94	5.4	0.6	89	153	2	99
	29	300	15	95	7.5	1.6	79	100	5	95
	30	185	10	95	6.9	1.1	84	25	7	72
	31	191	10	95	3.9	0.6	85	68	17	75
	Aug 1	216	19	91	4.0	0.6	85	46	4	91
	* 2	194	16	92	4.9	0.8	84	68	5	93
	* 3	211	15	93	4.4	1.0	77	119	8	93
	Average	219	12	94	5.5	0.9	85	82	7	88
	Maximum	300	19	96	7.5	1.6	89	153	17	99
	Minimum	185	9	91	3.9	0.6	79	25	2	72
#14	Aug 2/83	194	16	92	4.9	0.8	84	68	5	93
	3	211	15	93	4.4	1.0	77	119	8	93
	4	324	8	98	5.5	0.7	87	129	4	97
	5	217	6	97	6.1	0.6	90	124	4	97
	6	188	7	96	5.2	0.6	88	113	31	73
	7	185	5	97	4.0	1.0	75	61	8	87
	* 8	255	5	98	7.9	1.6	80	57	17	70
	* 9	220	14	94	4.8	1.8	63	76	12	84
	Average	220	10	96	5.0	0.8	84	102	10	90
	Maximum	324	16	98	6.1	1.0	90	129	31	97
	Minimum	185	5	92	4.0	0.6	75	61	4	73

* indicates sampling day

TABLE 16. SUMMARY OF THE PLANT BOD AND SUSPENDED SOLIDS MONITORING DATA FOR THE STUDY SAMPLING DAYS

SAMPLING DAY	SAMPLING DATES	TOTAL SUSPENDED SOLIDS						TOTAL BIOCHEMICAL OXYGEN DEMAND					
		COMBINED INFLUENT (mg/L)	PRIMARY EFFLUENT (mg/L)	PERCENT REMOVAL IN PRIMARY CLARIFIERS	FINAL EFFLUENT (mg/L)	PERCENT REMOVAL IN AERATION SECTION	OVERALL PERCENT REMOVAL	COMBINED INFLUENT (mg/L)	PRIMARY EFFLUENT	PERCENT REMOVAL IN PRIMARY CLARIFIERS	FINAL EFFLUENT (mg/L)	PERCENT REMOVAL IN AERATION SECTION	OVERALL PERCENT REMOVAL
#1	Dec. 6/82	748	118	84	43	64	94	194	83	57	23	72	88
	Dec. 7/82	175	111	37	16	86	91	107	53	50	22	77	89
	Average	462	115	61	30	75	93	151	68	54	23	75	89
#2	Dec. 20/82	208	82	61	17	79	92	111	45	59	13	71	88
	Dec. 21/82	256	109	57	19	83	93	153	67	56	16	76	90
	Average	232	96	59	18	81	93	132	56	58	15	74	89
#3	Jan. 5/83	731	108	85	18	83	98	145	49	66	12	76	92
	Jan. 6/83	188	97	48	20	79	89	180	64	64	13	80	93
	Average	460	103	67	19	81	93	163	57	65	13	78	92
#4	Jan. 11/83	248	128	48	24	81	90	133	80	40	14	83	89
	Jan. 12/83	259	130	50	20	85	92	127	90	29	13	86	90
	Average	254	129	49	22	83	91	130	85	35	14	85	90
#5	Jan. 19/83	228	151	34	19	87	92	133	71	47	9	87	93
	Jan. 20/83	379	113	70	19	83	95	144	119	17	11	91	92
	Average	304	132	52	19	85	94	139	95	32	10	89	93
#6	Jan. 25/26/83	12079	92	99	13	86	99.9	341	76	78	7	91	98
	Jan. 26/83	291	97	67	7	93	98	193	79	59	12	84	94
	Average	6185	95	83	10	90	99	267	78	69	10	88	96
WINTER AVERAGE		1316	112	62	20	83	94	164	73	52	14	82	90
#7	Apr. 13/83	190	98	48	8	92	96	103	61	41	7	89	93
	Apr. 14/83	178	132	26	9	93	95	88	67	24	7	90	92
	Average	184	115	37	9	93	95	96	64	33	7	90	93
#8	Apr. 21/83	312	114	63	11	90	96	186	79	58	5	94	97
	Apr. 22/83	246	97	61	5	95	98	120	59	51	3	95	98
	Average	279	106	62	8	93	97	153	69	55	4	95	97
#9	Apr. 26/83	192	94	51	7	93	96	117	83	29	4	95	97
	Apr. 27/83	320	99	69	5	95	98	119	88	26	6	93	95
	Average	256	97	60	6	94	97	118	86	28	5	94	96
#10	May 2/83	199	135	32	9	93	95	94	72	23	11	85	88
	May 3/83	205	96	53	19	80	91	104	46	62	12	74	88
	Average	202	116	43	14	87	93	99	59	43	12	80	88
SPRING AVERAGE		230	109	51	9	92	96	117	70	40	7	90	94
#11	June 22/83	250	62	75	11	82	96	121	45	63	14	69	88
	June 23/83	495	70	86	13	81	97	189	39	79	4	90	98
	Average	373	66	81	12	82	96	155	42	71	9	80	93
#12	July 11/83	225	63	72	7	89	97	137	40	71	8	80	94
	July 12/83	192	62	68	7	89	96	105	22	79	9	59	91
	Average	209	63	70	7	89	97	121	31	75	9	70	93
#13	Aug. 2/83	194	82	58	16	80	92	68	29	57	5	83	93
	Aug. 3/83	211	60	72	15	75	93	119	47	61	8	83	93
	Average	203	71	65	16	78	933	94	38	59	7	83	93
#14	Aug. 8/83	255	50	80	5	90	98	57	49	14	17	65	70
	Aug. 9/83	220	122	45	14	89	94	76	71	7	12	83	84
	Average	238	86	63	10	90	96	67	60	11	15	74	77
SUMMER AVERAGE		254	72	59	11	85	95	109	43	54	10	77	89
OVERALL AVERAGE		* 703	100	58	14	86	95	135	64	49	11	83	91

* WITHOUT JAN. 25/26 VALUE OVERALL AVERAGE = 281 mg/L.

TABLE 17. SUMMARY COMPARISON OF CONCENTRATIONS FOR CONVENTIONAL PARAMETERS MONITORED IN THE HAMILTON WPCP

PARAMETER	FLOW	AVERAGE MONTHLY CONCENTRATION				AVERAGE CONCENTRATION 1 WEEK PRIOR TO SAMPLING DAYS				AVERAGE CONCENTRATION ON SAMPLING DAYS			
		WINTER	SPRING	SUMMER	OVERALL	WINTER	SPRING	SUMMER	OVERALL	WINTER	SPRING	SUMMER	OVERALL
Suspended Solids	Influent	388	267	247	299	257	251	235	249	334*	230	254	281
	Effluent	16	12	11	13	15	10	10	12	20	9	10	14
BOD_5	Influent	146	117	121	128	132	119	112	123	164	117	109	135
	Effluent	12	8	13	11	11	6	10	9	13	7	10	11
Phosphorus	Influent	6.0	6.0	6.8	6.3	5.7	6.0	6.2	5.9	NA**	NA	NA	NA
	Effluent	1.1	0.9	1.3	1.1	1.3	0.8	1.1	1.1	NA	NA	NA	NA

* Winter average does not include uncharacteristically high value recorded on January 25, 1983.

** Results from WPCP laboratory phosphorus analysis not available on a daily basis.

On a monthly average basis, 202 mg/L of suspended solids were removed daily in the primary clarifiers, while the sampling day average was 181 mg of SS removed per litre of wastewater. This compares to the secondary treatment section which removed 84 mg/L of SS on a monthly average and a mean of 86 mg/L on the sampling days.

As would be expected, trends in the BOD results followed closely with those found in the suspended solids data. Daily BOD influent concentrations on, and one week prior to, the samplings were very close to monthly averages (monthly avg. = 128 mg/L, 1 week prior avg. = 123 mg/L, sampling day avg. = 135 mg/L).

Similarly, effluent concentrations on the sampling days were also close to the typical values, as there was a difference of only 1 mg/L between the study periods and routine monthly averages.

Despite good BOD removals in the aeration section of the plant, on a mass basis the primary clarifiers removed a greater portion of the total influent BOD. For example, the overall average reduction in BOD concentration in the primaries was 71 mg/L, while only 53 mg/L were removed in the secondary treatment facilities.

Although higher influent levels of total BOD were present in the winter months, the increased loading and colder temperatures of that period seemed to have little effect on the system's performance. In general, the effluent concentrations of BOD consistently met or bettered the 15 mg/L effluent requirement. Phosphorus levels in the influent were near 6.0 mg/L during all periods. Even though phosphorus removal chemicals are not added at the Hamilton plant, removal rates of 80-88% were achieved due to extremely high influent iron concentrations. The presence of iron in the wastewater brought phosphorus levels in the effluent down to an average concentration of 1.1 mg/L which is very close to the 1.0 mg/L MOE guideline.

The NH_3-N concentrations were only monitored across the secondary treatment facility and only recorded on a monthly basis. In general, there was little or no ammonia removal in the aeration basins and normally the wastewater was not nitrifying.

Finally, with the exception of one isolated result, the data collected on the individual sampling days was in good agreement with average weekly and monthly monitoring values. Thus, it can be concluded that the Hamilton WPCP was functioning within typical operating ranges during the study period.

3.3 Overall Treatment Efficiency Achieved

3.3.1 Conventional Parameters

The overall removal efficiencies for conventional parameters in the Hamilton WPCP are presented in Table 18. These values differ from the WPCP results in that this set of data represents independent samples taken by CANVIRO. The samples were analyzed outside of the WPCP facilities at either the CANVIRO laboratory in Kitchener or the MOE laboratory in Toronto, depending upon the analysis to be performed. Another important distinction between the WPCP sampling and the CANVIRO sampling was that the WPCP's routine monitoring samples were collected over a 24 hour span beginning at midnight on the sampling day, while the CANVIRO samples were also taken for 24 hours, but commenced at 9:00 a.m. on the sampling day. Thus, results from the same day cannot be compared directly.

The results summarized in Table 18 show good removals (+80%) for suspended solids and any suspended solids related parameters. The exception to this trend is the BOD removal rate of 53% during the winter season. This result however, should be considered questionable when compared to the WPCP monitoring data for the same sampling period, in which an average BOD removal rate of 90% was recorded.

Significant differences were apparent in all seasons between the effluent BOD concentrations measured by the MOE laboratory (Table 18) and those measured by the WPCP lab (Table 16). As a rule, the BOD concentrations detected by the MOE (overall avg. = 45.9 mg/L) exceeded the 15 mg/L effluent standard, while the WPCP results were generally lower than the 15 mg/L value (overall avg. = 11.0 mg/L).

Average phenol removal for the study period was 89.4% with the system reacting very well to large influent loadings of phenols on December 20-21 (1670 ug/L), April 26-27 (790 ug/L) and August 2-3 (1200 ug/L), maintaining a >99% removal efficiency for each of the three days. The average influent concentration of phenols (425.9 ug/L) was slightly higher than that found in the U.S. EPA study of 40 POTWs (U.S. EPA 1982a) which determined an average value of 364 ug/L. The 425.9 ug/L level was however, well below the influent concentration of 1.0 mg/L which the U.S. EPA suggested in their 30 day study of POTWs (U.S. EPA 1982b) would inhibit the operation of biological treatment systems.

TABLE 18. OVERALL REMOVAL EFFICIENCY FOR CONVENTIONAL PARAMETERS

SAMPLING DATE	WPCP FLOW (m^3/day)	SUSPENDED SOLIDS			BOD_5			COD			PHENOLICS		
		INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (ug/L)	EFF. (ug/L)	REMOVAL (%)
Dec 06-07	370,464	255.0	28.0	89.0	169.0	26.2	84.5	346	66	80.9	74.0	10.2	86.2
Dec 20-21	287,382	201.0	59.1	70.6	175.0	108.0	38.3	374	112	70.1	1670.0	3.0	99.8
Jan 05-06/83	270,130	165.0	14.0	91.5	160.0	150.0	6.3	322	344*	-6.8†	400.0	15.6	96.1
Jan 11-12	303,726	240.0	21.0	91.3	165.0	180.0*	-9.1†	380	1270*	-234†	13.2	6.6	50.0
Jan 18-19	233,810	211.0	22.0	89.6	272.0	330.0*	-21.3†	404	880*	-117.8†	58.0	2.2	96.2
Jan 25-26	272,854	249.0	12.0	95.2	168.0	28.7	82.9	1720?	84	95.1	15.0	4.2	72.0
WINTER AVERAGE	289,720	220.2	26.0	87.9	184.8	78.2	53.0	591	87.3	82.0	371.7	7.0	83.4
Apr 13-14	353,666	199.0	9.0	96.5	132.0	25.0	81.1	470	104	77.9	100.0	2.8	97.2
Apr 21-22	286,474	211.0	6.0	97.2	195.0	21.0	89.2	340	34	90.0	236.0	1.4	99.4
Apr 26-27	290,106	249.0	7.0	97.2	215.0	29.0	86.5	508	72	85.8	790.0	2.8	99.6
May 02-03	358,206	130.0	20.2	88.8	270.0	36.0	86.7	208	60	71.2	12.4	3.8	69.4
SPRING AVERAGE	322,113	209.8	10.6	94.7	203.0	28.8	85.9	382	67.5	81.2	284.6	2.7	91.4
July 11-12	268,768	96.8	10.3	89.4	340.0	29.0	91.5	1164?	52	95.5	188.0	5.4	97.1
Aug 02-03	276,032	137.0	5.7	95.8	200.0	6.1	97.0	896?	188	79.0	1200.0	3.4	99.7
Aug 08-09	314,622	182.0	12.6	93.1	126.0	561.1*	-345.3†	310	980*	-216.1†	780.0	3.2	99.6
SUMMER AVERAGE	286,474	138.6	9.5	92.8	222.0	17.6	94.3	790	120	87.3	723	4.0	98.8
OVERALL AVERAGE	298,941	198.0	17.5	91.1	199.0	45.9	74.4	572.5	85.8	82.8	425.9	5.0	89.4
MAXIMUM	370,464	255.0	59.1	97.2	340.0	150.0	97.0	1720	188	95.5	1670	15.6	99.8
MINIMUM	233,810	96.8	5.7	70.6	126.0	6.1	6.3	208	34	70.1	12.4	1.4	50.0

Notes: NR = No Result
* = Result confirmed by laboratory but still questionable and therefore not included in the mean.
† = Result questionable and therefore not included in the mean.
Data for June 22-23 is not available because samples were accidentally destroyed.
? = Very high COD results are not matched by similar increases for any other parameter: results could be questionable.

TABLE 18 (CONT'D). OVERALL REMOVAL EFFICIENCY FOR CONVENTIONAL PARAMETERS

SAMPLING DATE	WPCP FLOW (m^3/day)	TOTAL PHOSPHORUS			PHOSPHORUS (FILTERED)			TKN (UNFILTERED)			AMMONIA (FILTERED)		
		INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)	INF. (mg/L)	EFF. (mg/L)	REMOVAL (%)
Dec 06-07	370,464	3.18	1.9	40.2	1.38	1.36	1.4	31.6	18.5	41.5	25.5	17.8	30.2
Dec 20-21	267,332	5.65	1.09	80.7	2.68	0.48	82.1	38.8	27.0	30.4	24.5	19.5	20.4
Jan 05-06/83	270,130	5.40	1.05	80.6	2.20	0.44	80.0	37.7	29.5	21.8	24.5	24.5	0
Jan 11-12	303,726	5.90	1.25	78.8	1.86	0.70	62.4	33.7	21.0	37.7	19.2	17.6	8.3
Jan 18-19	233,810	6.00	1.12	81.3	1.60	0.40	75.0	46.2	NR*	NR*	35.0	25.2	28.0
Jan 25-26	272,854	7.00	0.70	90.0	2.10	0.20	90.5	40.3	30.0	25.6	25.0	24.0	4.0
WINTER AVERAGE	289,720	5.5	1.2	75.3	1.97	0.6	65.2	38.1	25.2	31.4	25.6	21.4	15.2
Apr 13-14	353,666	5.00	0.81	83.8	1.36	0.52	61.8	30.0	27.5	8.3	18.5	24.5	-32.4†
Apr 21-22	286,474	6.40	0.30	93.3	1.82	0.22	87.9	39.6	28.0	29.6	26.7	24.5	8.2
Apr 26-27	190,106	5.25	0.54	89.7	2.50	0.48	80.8	30.0	26.0	13.3	22.0	22.8	-3.6†
May 02-03	353,206	4.55	0.50	89.0	1.48	0.44	70.3	26.0	14.7	43.5	3.4	1.2	64.7
SPRING AVERAGE	320,863	5.3	0.54	89.0	1.79	0.42	75.2	31.5	24.1	23.7	17.7	18.3	36.5
July 11-12	268,768	3.50	1.75	50.0	1.08	1.38	-27.8*	31.0	15.3	51.6	20.8	13.2	36.5
Aug 02-03	276,032	4.15	0.88	78.8	1.88	0.51	72.9	30.5	11.6	62.0	NR	9.3	NR†
Aug 08-09	314,622	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SUMMER AVERAGE	286,474	3.83	1.3	64.4	1.48	0.95	72.9	30.8	13.5	56.8	20.8	11.3	36.5
OVERALL AVERAGE	298,553	5.2	0.99	78.0	1.8	0.59	69.6	34.6	22.6	33.2	22.3	18.7	22.3
MAXIMUM	370,464	7.0	1.75	93.3	2.68	1.38	90.5	46.2	30.0	62.0	35.0	25.2	64.7
MINIMUM	270,130	3.18	0.30	40.2	1.08	0.20	1.4	26.0	11.6	8.3	3.4	1.2	0.0

Notes: NR = No Result
* = Result confirmed by laboratory but still questionable and therefore not included in the mean.
† = Result questionable and therefore not included in the mean.
Data for June 22-23 is not available because samples were accidentally destroyed.

Total phosphorus effluent levels recorded were below or near the typical level of 1.0 mg/L suggested by the MOE for conventional activated sludge plants (MOE 1980), fluctuating from a minimum of 0.30 mg/L on April 21-22 to a maximum of 1.75 mg/L on July 11-12.

The percent removals of TKN and ammonia correlate well with results of the WPCP routine monitoring program, and confirm that nitrification was not occurring during the study period. Both influent and effluent ammonia concentrations (influent avg. = 22.3 mg/L; effluent avg. = 18.7 mg/L) were close to the typical discharge value of 17 mg/L given by the MOE in the "Guidelines for the Design of Sewage Treatment Works" (MOE 1980).

3.3.2 Trace Organics

3.3.2.1 PAHs

The results of the PAH analysis performed on the WPCP influent and effluent streams are presented in tabular form in Appendix B (Tables B-26 to B-33). These results show a trend towards higher influent and corresponding higher effluent PAH concentrations during the winter months. A possible explanation for this phenomenon is the warmer temperatures of the spring and summer seasons which may increase the reactivity of the PAHs and contribute to their decomposition prior to reaching the plant. This seasonal factor is discussed in more detail in Section 3.4.2.

Another notable characteristic of the PAH group was their tendency to be associated with the solid fraction rather than the liquid portion of the influent. An extreme example of this occurred during the winter sampling period when concentrations of naphthalene in the liquid phase of the influent were at or below detection limits, yet relatively high concentrations of the compound existed in the solid phase (21.3 ug/L). This general trend of concentration in the solid fraction did not carry through to the effluent, as in many cases, the effluent liquid fraction contained the majority of the PAH mass as shown by some examples in Table 19.

TABLE 19. COMPARISON OF THE AVERAGE CONCENTRATION OF SELECTED PAHs IN THE SOLID AND LIQUID FRACTIONS OF THE WPCP EFFLUENT

COMPOUND	SOLID FRACTION OF EFFLUENT		LIQUID FRACTION OF EFFLUENT	
	ug/L	grams/day	ug/L	grams/day
Naphthalene	0.01	3.0	0.27	80.0
Acenaphthylene	0.004	1.2	0.04	10.0
Dibenzofuran	0.01	4.0	0.11	30.0
Fluorene	0.008	2.3	0.18	50.0

The average influent concentration of naphthalene (13.4 ug/L) compared well with the average influent value 7 ug/L found in the U.S. EPA 40 plant study (U.S. EPA 1982a), despite an extremely large input of 119.1 ug/L during the second sampling day (December 20-21). This uncharacteristically high level of loading for December 20-21 was consistent for the six PAHs and two polynuclear heterocyclic compounds. The absence of any significant operational or environmental occurrences on that day would suggest that the high concentrations were due to an isolated shock load from an industrial source.

Table 20 provides a condensed summary of the removal efficiencies for PAHs in both the solid and liquid fractions of the wastewater as well as indicating the overall percent removals. For convenience the two heterocyclic compounds carbazole and dibenzofuran, have been grouped with the PAHs for discussion throughout the remainder of this report.

The overall removals of the individual PAHs ranged from 94% for naphthalene to essentially 100% for acenaphthylene. The overall percent removal for the combined group of PAHs was 97%. Removals within the liquid and solids fractions were in the same range, being divided approximately equally between the two fractions for all the compounds except for naphthalene which had a slightly lower average removal (89%) in the liquid fraction. This was partially due to the extremely low concentrations of naphthalene in the liquid fraction during the winter sampling period. It should be noted that three isolated results of uncharacteristically low PAH removal efficiencies were recorded in Table 20 (50% for dibenzofuran on Apr. 26-27, 65.2% for naphthalene on May 2-3, and 68.1% for fluorene on Apr. 26-27). The low removals were all observed on sampling days when influent loadings of the specific contaminants were very low and corresponding effluent levels were at or near average values. Therefore, despite the typically low concentrations present in the effluent, the associated removal efficiencies calculated for those periods were extremely low.

TABLE 20. OVERALL REMOVAL EFFICIENCY FOR PAHs

	NAPHTHALENE PERCENT REMOVAL			ACENAPHTHYLENE PERCENT REMOVAL			DIBENZOFURAN PERCENT REMOVAL			FLUORENE PERCENT REMOVAL			CARBAZOLE PERCENT REMOVAL			PYRENE PERCENT REMOVAL			BENZO(a)PYRENE PERCENT REMOVAL		
	S. FRAC.	L. FRAC.	TOTAL	S. FRAC.	L. FRAC.	TOTAL	S. FRAC.	L. FRAC.	TOTAL	S. FRAC.	L. FRAC.	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL
Dec 06-07	99.22	TV	99.22	100.00	100.00	100.00	100.00	100.00	100.00	99.54	100.00	99.71	94.19	100.00	99.69	89.02	50.00	83.77	97.29	93.75	96.61
Dec 20-21	99.96	INV	INV	100.00	100.00	100.00	100.00	98.15	99.14	99.96	96.83	98.67	96.67	100.00	98.90	98.59	99.23	98.69	99.20	TV	99.20
Jan 05-06/83	99.29	TV	99.29	99.67	100.00	99.91	99.67	100.00	99.82	99.70	100.00	99.86	89.39	100.00	96.12	88.88	75.00	86.85	97.64	100.00	98.15
Jan 11-12	100.00	TV	100.00	100.00	100.00	100.00	96.02	100.00	97.56	100.00	100.00	100.00	100.00	100.00	100.00	94.60	100.00	95.38	94.71	100.00	96.67
Jan 18-19	98.70	TV	98.70	99.35	100.00	99.75	99.26	100.00	99.65	99.63	100.00	99.77	92.49	100.00	96.86	95.64	100.00	96.07	98.54	100.00	99.07
Jan 25-26	100.00	TV	100.00	100.00	100.00	100.00	99.83	100.00	99.88	99.85	100.00	99.92	98.10	100.00	98.59	97.11	100.00	97.33	100.00	100.00	100.00
WINTER AVERAGE	99.53	INV	99.44	99.84	100.00	99.94	99.13	99.69	99.34	99.78	99.47	99.66	95.14	100.00	97.86	93.97	87.37	93.02	97.90	98.75	98.28
Apr 13-14	100.00	100.00	100.00	97.74	100.00	99.49	97.29	100.00	98.52	98.71	100.00	99.21	93.38	100.00	96.18	94.05	100.00	94.90	97.18	100.00	97.86
Apr 21-22	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.29	100.00	99.17	97.63	100.00	99.97	99.09	100.00	99.24
Apr 26-27	100.00	94.44	94.79	100.00	TV	TV	TV	50.00	50.00	100.00	50.00	68.09	97.75	97.06	97.35	97.19	100.00	97.65	99.09	100.00	99.32
May 02-03	100.00	50.00	65.22	TV	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.98	95.00	93.69	91.98	100.00	93.60	96.26	100.00	97.05
SPRING AVERAGE	100.00	86.11	90.00	99.25	100.00	99.83	99.10	87.50	87.13	99.68	87.50	91.82	95.35	98.02	96.60	95.21	100.00	96.03	97.91	100.00	98.37
June 22-23	95.60	TV	TV	INV	INV	INV	100.00	100.00	100.00	99.69	100.00	99.79	97.96	100.00	98.87	98.31	100.00	98.58	98.68	100.00	98.92
July 11-12	100.00	83.33	85.09	TV	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.01	100.00	99.21	96.96	100.00	97.93	97.91	100.00	98.71
Aug 02-03	97.23	95.83	95.89	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	96.91	100.00	99.36	97.23	100.00	97.82	99.78	100.00	99.87
Aug 08-09	96.54	100.00	99.87	93.08	100.00	99.37	100.00	100.00	100.00	100.00	100.00	100.00	93.47	100.00	97.95	96.31	100.00	97.00	99.02	100.00	99.39
SUMMER AVERAGE	97.34	93.05	93.62	96.54	100.00	99.79	100.00	100.00	100.00	99.92	100.00	99.95	95.84	100.00	98.85	97.20	100.00	97.85	98.85	100.00	99.22
OVERALL AVERAGE	99.04	89.09	94.84	99.08	100.00	99.88	99.39	96.30	96.04	99.79	96.20	97.50	95.40	99.43	97.98	95.25	94.59	95.26	98.17	99.52	98.58
MAXIMUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.59	100.00	98.69	100.00	100.00	100.00
MINIMUM	95.60	50.00	65.22	93.08	100.00	99.37	96.02	50.00	50.00	98.71	50.00	68.09	89.39	95.00	93.69	88.88	50.00	83.77	94.71	93.75	96.61

Notes: INV = Invalid Result
TV = Only Trace Values detected

The treatment plant efficiency for acenaphthylene and benzo(a)-pyrene removal was extremely good. Efficiencies for the two contaminants were in the 98-100% range and the effluent streams contained only traces of either compound (e.g. <1.0 ug/L).

Fluoranthene, fluorene and pyrene influent levels were compatible with the 0 to 12 ug/L range found in the EPA 30 day study (U.S. EPA 1982b). Effluent values varied from almost non-detectable levels of fluoranthene to a 5.0 ug/L concentration of pyrene resulting from the excessive loading of December 20-21. The overall removal efficiencies of 95-96% reflected the systems ability to consistently remove fluoranthene, fluorene and pyrene at the influent concentrations encountered (i.e. 1.5 ug/L - 420 ug/L).

The system generally responded well to large doses of trace organics, actually attaining higher than average removal rates for the increased loads of the December 20-21 period.

3.3.2.2 PCBs and Pesticides

Twenty-four hour composite samples were submitted to the MOE Laboratory for chlorinated pesticides, PCB's and chlorinated phenols analyses (see Table 7 on p. 23 for specific contaminants analyzed). Of the 28 compounds or groups of compounds monitored, lindane, total PCB's and pentachlorophenol were the only compounds consistently detected in the Hamilton WPCP influent and effluent samples. Tables B-34 to B-36 in Appendix B summarizes the treatment of lindane, total PCB and pentachlorophenol in the Hamilton WPCP. A condensed table of removal efficiencies for the three compounds follows in Table 21.

Removals of lindane ranged from a low of 16.7% to 100% and did not exhibit any distinct trends. The large variance in treatment efficiency was probably related to the minute quantities of lindane which were detected. Influent concentrations in both the solid and liquid phase were, all below 1.0 ug/L. Consequently, effluent values were usually below the detection limit, making the value of the removal data questionable.

Shannon (1976) examined PCB concentrations in 33 wastewater treatment plants in Ontario and found that influent loadings ranged from the detection limit (0.01 ug/L) to 1.8 ug/L. Comparison of the influent PCB values in Table B-35 shows that the PCB input into the Hamilton WPCP was in the range reported by Shannon (1976), with an overall average of 0.13 ug/L of PCB being present in the Hamilton influent during this study period.

The overall removal efficiency of polychlorinated biphenyls was good (90%) with an overall concentration in the effluent of 0.03 ug/L during the study.

TABLE 21. OVERALL REMOVAL EFFICIENCY FOR PCBs AND PESTICIDES

	LINDANE PERCENT REMOVAL			TOTAL PCB PERCENT REMOVAL			PENTACHLOROPHENOL PERCENT REMOVAL		
	S. FRAC.	L. FRAC.	TOTAL	S. FRAC.	L. FRAC.	TOTAL	S. FRAC.	L. FRAC.	TOTAL
Dec 06-07	TV	INV	INV	81.21	INV	INV	ND	ND	ND
Dec 20-21	TV	100.00	100.00	71.43	76.19	74.26	100.00	TV	100.00
Jan 05-06/83	TV	43.19	43.19	100.00	76.47	78.74	95.76	TV	95.76
Jan 11-12	TV	64.03	64.03	94.17	TV	94.76	100.00	11.11	29.82
Jan 18-19	TV	86.86	86.86	91.31	TV	91.31	TV	30.43	30.43
Jan 25-26	TV	91.67	91.67	97.78	100.00	99.48	100.00	11.11	45.68
WINTER AVERAGE	INV	77.15	77.15	89.32	84.22	87.59	98.94	17.55	60.34
Apr 13-14	100.00	100.00	100.00	100.00	TV	100.00	INV	44.12	INV
Apr 21-22	INV	INV	INV	INV	73.33	INV	86.73	TV	86.73
Apr 26-27	100.00	42.11	42.21	99.35	100.00	99.62	ND	ND	ND
May 02-03	ND	ND	ND	INV	INV	INV	ND	ND	ND
SPRING AVERAGE	100.07	80.70	71.10	99.68	86.67	99.81	86.73	44.12	86.73
June 22-23	ND	ND	ND	TV	100.00	100.00	TV	65.88	65.88
July 11-12	TV	16.67	16.67	81.99	42.86	71.41	97.54	20.00	32.05
Aug 02-03	100.00	85.71	86.12	93.37	63.64	84.51	91.26	80.00	80.15
Aug 08-09	ND	ND	ND	93.18	100.00	94.29	INV	INV	INV
SUMMER AVERAGE	100.00	351.19	51.39	89.51	76.63	87.55	92.78	55.29	59.36
OVERALL AVERAGE	100.00	73.08	70.08	91.25	81.39	89.80	95.10	37.52	62.94
MAXIMUM	100.00	100.00	100.00	100.00	100.00	100.00	100.00	80.00	100.00
MINIMUM	100.00	16.67	16.67	71.43	42.86	71.43	86.73	11.11	29.82

Notes: ND = Not Detected
INV = Invalid Result
TV = Trace Value

Pentachlorophenol (PCP) differed from the PCBs in that it was present mainly in the liquid fraction of the wastewater. Influent concentrations ranged from non-detectable to 1.01 ug/L with the highest levels being recorded during the winter. Although an overall removal efficiency of 63% for pentachlorophenol was determined from the testing, on days when the influent contained more than trace amounts of the compound, removal was over 80%. This meant that effluent levels of pentachlorophenol were quite low (avg. = 0.1 ug/L) and were commonly at or below the detection limit (0.001 ug/L).

3.3.3 Trace Metals

The results of the trace metal analysis performed on the WPCP influent and effluent streams are presented in tabular form in Appendix B (Tables B-37 - B-49).

Table 22 provides a summary of the removal efficiencies for metals in both the liquid and solid fractions of the wastewater as well as indicating the overall percent removals. Results were not obtained for trace metal concentrations on the second sampling day (December 20-21), and thus, the metals analysis is based on thirteen samples rather than fourteen.

Removals of trace metals in the WPCP correlated well to influent concentrations as periods of high removal efficiency corresponded directly to periods of high metal loadings. Brown (1973) found the same trend in his study of the efficiency of municipal sewage treatment plants, in which he examined the removal of five metals (Cu, Cr, Zn, Pb, Cd).

Patterson and Shimada (1975) asserted that there is a direct relationship between the behaviour of suspended solids and trace metals in biological treatment systems. The present study results do not distinctly verify this. However, some correlation between metal removals and suspended solids removals did exist. For instance, removal rates of the heavy metals and suspended solids peaked during the spring season, during which >85% of the influent metals mass (excluding nickel) was removed by the Hamilton plant.

Trace metals removals were generally better accomplished in the solid fraction of the wastewater than in the liquid fraction. However, there was some variance in this trend due to fluctuations in the liquid/solid composition of the influent wastewater. In addition to composition variation, deviations in the degree of metals loading were also common. For example,

TABLE 22. OVERALL REMOVAL EFFICIENCY FOR TRACE METALS

	IRON PERCENT REMOVAL			ALUMINUM PERCENT REMOVAL			ARSENIC PERCENT REMOVAL			CADMIUM PERCENT REMOVAL			CHROMIUM PERCENT REMOVAL			COPPER PERCENT REMOVAL		
	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL
Dec 06-07	ND	ND	ND	88.88	48.84	81.91	83.36	TV	83.36	77.70	TV	77.70	82.89	90.00	85.29	88.85	0.00	83.72
Dec 20-21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Jan 05-06/83	94.34	90.00	93.42	94.59	95.36	95.09	92.52	TV	92.52	93.54	TV	93.54	92.16	100.00	93.37	94.23	100.00	95.06
Jan 11-12	93.88	89.41	93.02	94.14	60.78	87.99	ND	ND	ND	87.94	TV	87.94	92.95	83.33	90.47	92.91	25.00	77.75
Jan 18-19	92.55	93.20	92.69	87.26	45.95	77.13	ND	ND	ND	89.57	TV	89.57	86.93	100.00	89.95	90.00	83.33	88.50
Jan 25-26	97.47	92.67	97.02	99.85	51.35	92.64	ND	ND	ND	94.13	TV	94.13	95.61	100.00	96.47	96.27	100.00	96.70
WINTER AVERAGE	94.56	91.32	94.04	92.94	60.46	86.95	87.94	INV	87.94	88.58	INV	88.58	90.11	94.67	91.11	92.65	61.67	88.35
Apr 13-14	97.35	INV	INV	94.42	52.63	87.08	94.13	TV	94.13	93.83	TV	93.83	93.77	100.00	94.67	95.59	INV	INV
Apr 21-22	97.99	70.00	91.16	96.89	INV	INV	95.14	TV	95.14	97.29	TV	97.29	96.31	TV	96.31	97.19	INV	INV
Apr 26-27	97.80	96.52	97.53	97.90	8.70	87.85	99.64	TV	99.64	98.26	TV	98.26	96.91	100.00	97.53	97.80	87.50	94.41
May 02-03	93.88	100.00	94.53	92.18	96.81	95.57	91.04	TV	91.04	90.94	TV	90.94	93.53	100.00	95.15	91.09	100.00	93.35
SPRING AVERAGE	96.75	88.84	94.41	95.34	52.71	90.17	94.99	INV	94.99	95.08	INV	95.08	95.13	100.00	95.92	95.42	93.75	93.88
June 22-23	ND	ND	ND	95.25	26.67	83.35	98.96	TV	98.96	93.23	TV	93.23	92.39	100.00	93.46	94.00	100.00	94.93
July 11-12	92.12	INV	INV	92.34	INV	INV	4.24	TV	4.24	92.02	TV	92.02	94.48	76.92	78.26	91.72	INV	INV
Aug 02-03	96.02	95.24	95.77	96.33	26.47	71.43	94.19	TV	94.19	95.57	TV	95.57	97.97	71.43	88.01	96.58	50.00	86.86
Aug 08-09	93.65	88.33	92.65	94.60	26.92	77.42	97.05	TV	97.05	93.37	TV	93.37	94.01	91.67	93.24	95.46	33.33	84.34
SUMMER AVERAGE	93.93	91.79	94.21	94.63	26.69	77.40	73.61	INV	73.61	93.55	INV	93.55	94.71	85.00	88.24	94.44	61.11	88.71
OVERALL AVERAGE	95.19	90.60	94.20	94.20	49.13	85.22	85.23	INV	85.23	92.11	INV	92.11	93.07	92.78	91.71	94.05	67.92	89.56
MAXIMUM	97.99	100.00	97.53	99.85	96.81	95.57	99.64	INV	99.64	98.26	INV	98.26	97.97	100.00	97.53	97.80	100.00	96.70
MINIMUM	92.55	70.00	91.16	87.26	8.70	77.13	4.24	INV	4.24	77.70	INV	77.70	82.89	71.43	78.26	88.85	0.00	77.75

Notes: ND = Not Detected
INV = Invalid Result
TV = Trace Value

TABLE 22 (CONT'D). OVERALL REMOVAL EFFICIENCY FOR TRACE METALS

	MERCURY PERCENT REMOVAL			NICKEL PERCENT REMOVAL			LEAD PERCENT REMOVAL			SELENIUM PERCENT REMOVAL			ZINC PERCENT REMOVAL		
	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL	S FRAC	L FRAC	TOTAL
Dec 06-07	94.98	100.00	95.60	88.33	20.00	50.70	88.83	ND	88.83	50.52	ND	50.52	84.53	75.00	82.85
Dec 20-21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Jan 05-06/83	95.76	82.35	92.15	94.84	40.00	63.66	94.75	ND	94.75	93.28	ND	93.28	93.64	71.43	88.98
Jan 11-12	ND	ND	ND	96.02	40.00	74.34	94.78	ND	94.78	ND	ND	ND	91.76	68.75	85.28
Jan 18-19	ND	ND	ND	91.24	14.29	47.36	95.26	INV	INV	ND	ND	ND	88.08	66.67	80.87
Jan 25-26	96.21	100.00	96.77	97.19	16.67	64.90	96.89	100.00	97.55	ND	ND	ND	95.18	44.44	84.77
WINTER AVERAGE	95.65	94.12	94.84	93.52	26.19	60.19	94.10	100.00	93.98	71.90	ND	71.90	90.64	65.26	84.55
Apr 13-14	95.71	75.00	93.09	92.81	20.00	45.93	95.61	75.00	89.17	90.11	ND	90.11	93.75	INV	INV
Apr 21-22	96.94	50.00	89.88	98.27	TV	98.27	97.82	INV	INV	93.33	INV	INV	97.19	99.65	99.63
Apr 26-27	98.36	42.86	90.49	98.00	20.00	61.47	98.26	ND	98.26	99.25	ND	99.25	97.54	68.75	88.98
May 02-03	90.23	33.33	85.15	93.35	60.00	77.23	95.10	ND	95.10	84.20	ND	84.20	93.24	69.57	86.38
SPRING AVERAGE	95.31	50.30	89.65	95.61	33.33	70.73	96.70	75.00	94.18	93.22	ND	91.19	95.43	79.32	91.66
June 22-23	ND	ND	ND	97.96	0.00	65.10	97.77	100.00	98.01	92.06	ND	92.06	95.70	15.38	66.92
July 11-12	93.08	11.11	67.30	95.96	14.29	19.57	96.84	ND	96.84	INV	INV	INV	95.53	39.13	44.50
Aug 02-03	95.13	0.00	70.68	96.29	INV	INV	96.25	ND	96.25	90.86	ND	90.86	96.63	58.33	77.81
Aug 08-09	TV	50.00	50.00	95.48	33.33	70.66	96.83	100.00	97.31	84.31	ND	84.31	93.94	44.44	74.42
SUMMER AVERAGE	94.11	20.37	62.66	96.47	15.87	51.78	96.92	100.00	97.10	89.08	ND	89.08	95.45	39.32	65.91
OVERALL AVERAGE	95.16	54.38	83.11	95.06	25.32	61.60	95.77	93.75	95.17	87.10	INV	85.57	93.59	60.13	80.12
MAXIMUM	98.36	100.00	96.77	98.27	60.00	98.27	98.26	100.00	98.26	99.25	INV	99.25	97.54	99.65	99.63
MINIMUM	90.23	0.00	50.00	88.33	0.00	19.57	88.83	75.00	88.83	50.52	INV	50.52	84.53	15.38	44.50

Notes: ND = Not Detected
INV = Invalid Result
TV = Trace Value

influent concentrations of aluminum varied from 434 ug/L on July 11-12 to 6413 ug/L on May 2-3, while iron levels ranged from 1846 ug/L on July 11-12 to 16,191 ug/L on January 25-26. These observed deviations support Oliver and Cosgrove's (1973) assertion that if a municipal treatment plant serves a heavily industrialized area, then trace metal inputs to the plant will occur in isolated slugs. The slugs are the result of non-periodic high discharges from various contributing industrial sources.

The best metal removal efficiencies were achieved for iron and lead (95% average removal). However, due to high influent concentrations, the effluent concentrations of iron were also high (488 ug/L average). The presence of iron contributes to the precipitation of phosphorus within the plant, and thus, the addition of a phosphorus removal chemical is not practiced at the Hamilton plant to meet the phosphorus objective of 1 mg/L.

A group of metals including arsenic, aluminum, cadmium, chromium, copper, mercury, selenium and zinc were all removed effectively by the WPCP with percent reductions ranging from 80% for zinc to 92% for cadmium. It is noteworthy that despite the industrial presence in Hamilton, these metals all had influent and effluent concentrations below the average levels recorded by Environment Canada in its study on metal sources in municipal wastewaters of Ontario (Environment Canada 1978). Table 23 provides a comparison between the metal concentrations observed in the Hamilton WPCP and the average values found by Environment Canada (1978).

TABLE 23. COMPARISON OF HAMILTON WPCP AND AVERAGE ONTARIO MUNICIPAL WASTEWATER TREATMENT PLANT TRACE METAL CONCENTRATIONS

METAL	HAMILTON WPCP AVERAGE CONCENTRATIONS (THIS STUDY) (mg/L)		20 ONTARIO WPCP AVERAGE CONCENTRATIONS (ENVIRONMENT CANADA) (mg/L)	
	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Al	2.2	0.4	3.8	0.47
As	0.002	<0.001	0.005	0.001
Cd	0.001	<0.001	0.02	<0.01
Cr	0.21	0.02	0.97	0.09
Cu	0.13	0.02	0.30	0.06
Hg (ug/L)	0.26	0.03	1.03	0.07
Se	0.001	Invalid	0.003	<0.001
Zn	3.3	0.09	1.12	<0.28

The average percent removal for nickel was characteristically lower than the other metals, but at 62% was much greater than the typical nickel removals found in other studies of activated sludge plants (Oliver and Cosgrove 1973, avg. Ni removal = 16-18%; M.M. Nomura 1974, avg. Ni removal = 42%).

3.3.4 Summary of Annual Loadings of HCs

An evaluation of the annual loadings of hazardous contaminants entering the Hamilton WPCP is given in Table 24. The annual loadings were developed for each specific contaminant and were calculated from the overall mean loadings for the sampling days. The annual influent PAH loadings ranged from 613 kg for acenaphthylene to 4420 kg for benzo(a)pyrene, while annual effluent masses ranged from 4.1 kg for acenaphthylene to 84 kg for pyrene. Acenaphthylene and carbazole were the only PAHs which concentrated to a greater extent in the liquid fraction of the influent wastewater. However acenaphthylene, dibenzofuran, fluorene and naphthalene were all associated with the liquid fraction of the effluent.

The annual PCB loading entering the Hamilton WPCP was 14.7 kg/yr. Almost 75% of the influent polychlorinated biphenyls were concentrated in the solid phase of the wastewater, while on the contrary, 75% of the effluent PCB mass was concentrated in the liquid phase.

The trace metals could be divided into two distinct groups in terms of loading quantity:

i) a group including iron, aluminum, chromium, copper, nickel, lead and zinc which were consistently present in large amounts. (e.g. 5,000-700,000 kg/yr in the influent; 600-50,000 kg/yr in the effluent); and

ii) a group including arsenic, cadmium, mercury and selenium which were intermittently present in small quantities (e.g. 20-300 kg/yr in the influent; 5-50 kg/yr in the effluent).

TABLE 24. ESTIMATED ANNUAL LOADINGS OF HAZARDOUS CONTAMINANTS ENTERING AND BEING DISCHARGED FROM THE HAMILTON WPCP

HAZARDOUS CONTAMINANT	DAILY LOADING (kg/d)						ANNUAL LOADING (kg/yr)					
	INFLUENT			EFFLUENT			INFLUENT			EFFLUENT		
TRACE ORGANICS	SOLID FRAC.	LIQUID FRAC.	TOTAL	SOLID FRAC.	LIQUID FRAC.	TOTAL	SOLID FRAC.	LIQUID FRAC.	TOTAL	SOLID FRAC.	LIQUID FRAC.	TOTAL
Naphthalene	2.75	1.17	3.91	0.003	0.08	0.083	1004	427	1431	1.1	29.2	30.3
Acenaphthylene	0.66	1.02	1.68	0.001	0.01	0.011	241	372	613	0.4	3.7	4.1
Dibenzofuran	1.66	1.49	3.15	0.004	0.03	0.034	606	544	1150	1.4	11.0	12.4
Fluorene	2.43	1.75	4.18	0.002	0.05	0.052	887	639	1526	0.7	18.3	19.0
Fluoranthene	9.11	2.03	11.13	0.15	0.03	0.18	3325	741	4066	54.8	11.0	65.7
Carbazole	2.53	3.79	6.33	0.10	0.02	0.12	924	1383	2310	36.5	7.3	43.8
Pyrene	8.52	1.63	10.15	0.20	0.03	0.24	3110	595	3705	73.0	11.0	84.0
Benzo(a)pyrene	9.47	2.63	12.11	0.18	0.01	0.19	3457	960	4420	65.7	3.7	69.4
Lindane	0.0	0.02	0.02	0.0	0.01	0.01	0.0	7.3	7.3	0.0	3.7	3.7
Total PCBs	0.03	0.01	0.04	0.003	0.008	0.011	11.0	3.7	14.7	1.1	2.9	4.0
Pentachlorophenol	0.004	0.06	0.06	0.0	0.03	0.03	1.5	21.9	23.4	0.0	11.0	11.0
TRACE METALS												
Iron	1677	357	2034	71.4	68.4	139.8	612105	130305	742410	26061	24966	51027
Aluminum	416	271	687	23.9	83.8	107.7	151840	98915	250755	8724	30587	39311
Arsenic	0.6	0.0	0.6	0.04	0.0	0.04	219	0	219	14	0	15
Cadmium	0.3	0.0	0.3	0.03	0.0	0.03	110	0	110	11	0	11
Chromium	43.7	18.4	62.1	3.0	2.5	5.5	15951	67160	83111	1095	913	2008
Copper	32.4	7.3	39.7	1.95	3.6	5.6	11826	2665	14491	712	1314	2026
Mercury	0.06	0.02	0.08	0.003	0.007	0.01	21.9	7.3	29.2	1.1	2.6	4
Nickel	13.9	13.1	27.0	0.65	10.2	10.9	5074	4782	9892	237	3723	3979
Lead	26.8	2.2	29	1.3	0.6	1.9	9782	803	10585	475	219	694
Selenium	0.46	0.0	0.5	0.09	0.0*	0.0*	168	0	183	33	0	33
Zinc	92.0	857	949	6.8	20.7	27.5	33580	312805	346385	2482	7556	10038

* Questionable effluent selenium value recorded for April 21-22 omitted in calculation of average.

The trace metals in the first group (e.g. iron, etc.) concentrated to a considerable degree in both the solid and liquid fractions of the wastewater, while the metals in the second group, with the exception of selenium, existed mainly in the liquid fraction of both the influent and effluent.

3.4 Assessment of Factors Affecting Removals of Hazardous Contaminants

3.4.1 General

The factors which potentially affect the removal of hazardous contaminants in municipal WPCP's have been broadly categorized into two groups for purposes of this study:

i) Seasonal effects and miscellaneous factors including influent contaminant concentrations.

ii) Design and operational characteristics of the WPCP.

As discussed in Section 2.1, sampling and analysis of specific contaminants was carried out over three time periods representing three seasons (winter, spring, summer). No attempt was made to control the influent flows or contaminant concentrations, nor interfere with the normal operation of the plant. Rather, these factors were merely observed, recorded and subsequently correlated to HC removals in order to identify the factors which affected removals of the HCs monitored. Therefore, for trends to be apparent regarding seasonal or operational factors affecting HC removal efficiency, there would have to be significant variability in HC removal from day to day or season to season during the study. From the discussion of overall treatment efficiencies in the previous section this was not the case.

Since no obvious cause and effect relationships were evident from the assessment of overall plant performance a more detailed study of seasonal and design/operational factors was undertaken as discussed in the following sections.

3.4.2 Seasonal Factors

Although it is generally recognized that temperature fluctuations influence the removal of BOD and other conventional parameters, the results of this study provide no definite evidence that would suggest seasonal

changes had any significant effect on the treatability of HCs within the Hamilton WPCP. It was found that generally the removals of all HCs studied were good (e.g. >90% for organics; >80% for metals) regardless of the season.

The lack of significant seasonal variation in HC removal at the Hamilton WPCP is depicted in Figure 5, which shows removal efficiencies for the three groups of contaminants monitored during the study (e.g. PAHs, PCBs and trace metals). The plots in Figure 5 indicate that the PAHs were generally within ± 5% of their 97% mean removal efficiency, while the trace metals and PCBs ranged ± 15% about their respective mean removal efficiencies of 85% and 90%.

Although removal efficiencies did not vary substantially throughout the year, there were seasonal influences apparent in the contaminant concentratio· entering the WPCP. Generally, influent concentrations of the semi-volatile PAH group were higher in both the solid and liquid phase during the winter months (see Table 25). This could be due to the occurrence of some metabolization or volatilization of the trace organics in the warmer spring and summer seasons, prior to reaching the treatment plant. Conversely influent levels of PCBs were highest during the summer season due mainly to a relatively heavy loading of 0.1 kg which occurred on August 8.

Table 26 summarizes the seasonal mass loadings for seven of the trace metals. The results indicate that influent metal loadings peaked during the spring for both solid and liquid fractions of the wastewater. This trend was also found in the EPA 40 plant study (1982a) and was attributable to increased precipitation during the spring period which scoured metal deposits from runoff surfaces, and subsequently resulted in high plant influent loadings for that season.

A further cause of excessive influent contaminant concentrations is the presence of industrial sources within the area. During cleanup operations or peak production periods, a particular industry or group of industries may account for shock loads of pollutants in the WPCP influent.

In general, the results of this study and others (e.g. U.S. EPA 1982a), have shown that up to extremely high inhibitory pollutant concentrations, the percent removal of HCs in municipal treatment plants are relatively constant.

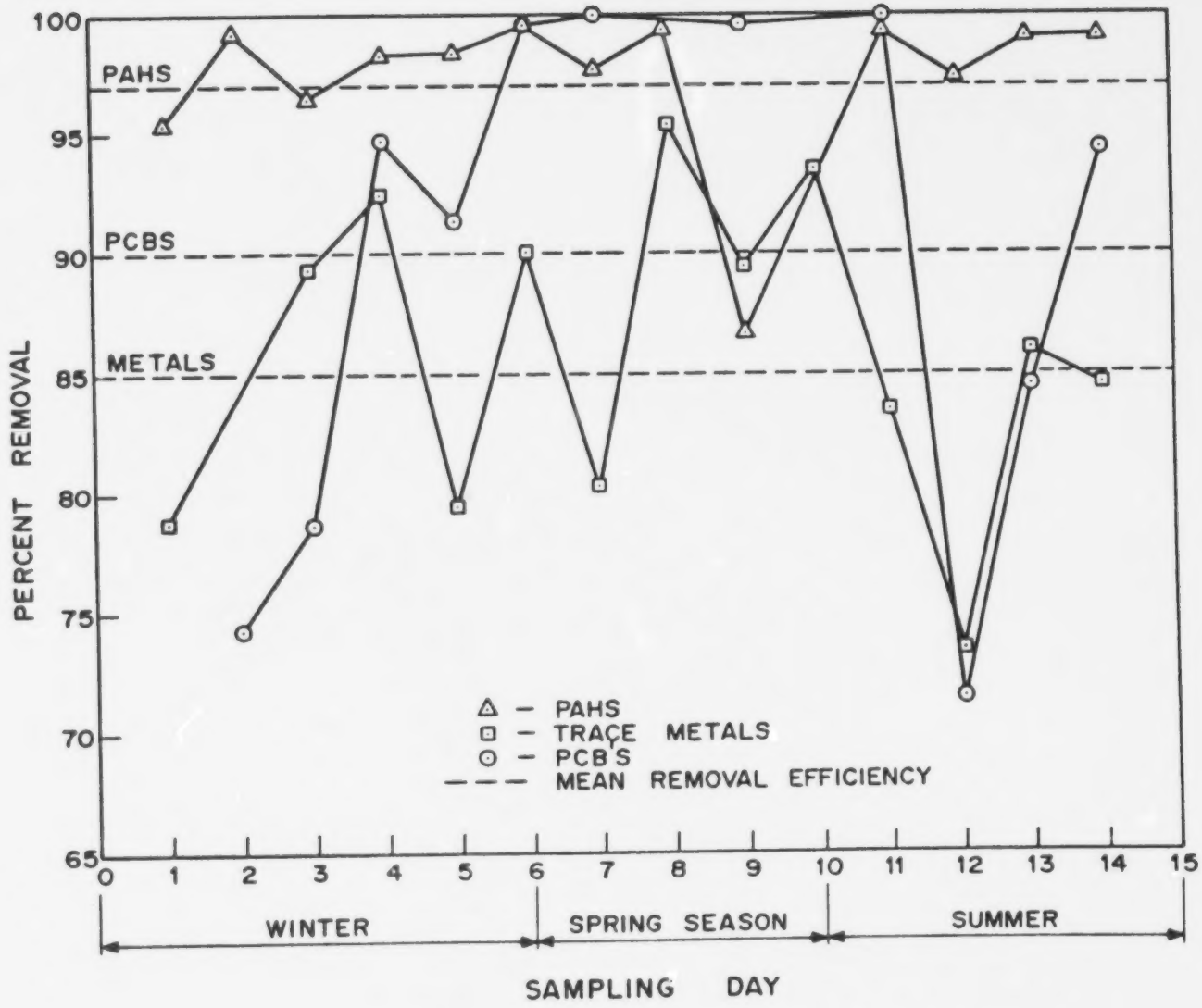


FIGURE 5 – SEASONAL VARIATION OF CONTAMINANT REMOVAL EFFICIENCIES

TABLE 25. SEASONAL COMPARISON OF INFLUENT LOADINGS OF TRACE ORGANICS ENTERING THE HAMILTON WPCP

TRACE ORGANICS	WINTER			SPRING			SUMMER		
	SOLID FRACTION	LIQUID FRACTION	TOTAL	SOLID FRACTION	LIQUID FRACTION	TOTAL	SOLID FRACTIO	LIQUID FRACTION	TOTAL
Naphthalene	6.14	0.0	6.14	0.28	1.64	1.92	0.13	2.44	2.57
Acenaphthylene	1.42	1.87	3.29	0.10	0.45	0.55	0.08	0.31	0.39
Dibenzofuran	3.64	2.98	6.62	0.19	0.32	0.51	0.18	0.42	0.60
Fluorene	5.26	3.67	8.93	0.31	0.33	0.64	0.30	0.29	0.59
Fluoranthene	19.42	4.32	23.74	1.50	0.26	1.76	1.25	0.34	1.59
Carbazole	2.68	3.64	6.32	2.80	3.23	6.03	2.04	4.59	6.63
Pyrene	18.12	3.40	21.52	1.62	0.31	1.93	1.03	0.27	1.30
Benzo(a)pyrene	14.77	3.34	18.11	6.18	1.74	7.92	4.83	2.46	7.29
Average of PAHs	8.93	2.90	11.8	1.62	1.04	2.66	1.23	1.39	2.62
Total PCBs	0.03	0.02	0.05	0.01	0.01	0.02	0.04	0.01	0.05
Pentachlorophenol	0.006	0.02	0.026	0.001	0.03	0.031	0.005	0.16	0.165
Organics Average	7.15	2.32	9.45	1.30	0.83	2.13	0.99	1.13	2.12

Notes:
i) Lindane was not present in quantities large enough to establish trends.
ii) All loadings in kg/day.
iii) These estimates are based on average values from individual sampling days and include extreme values measured on one or two days for most contaminants.

TABLE 26. SEASONAL COMPARISON OF INFLUENT LOADINGS OF TRACE METALS ENTERING THE HAMILTON WPCP

TRACE METALS	WINTER			SPRING			SUMMER		
	SOLID FRACTION	LIQUID FRACTION	TOTAL	SOLID FRACTION	LIQUID FRACTION	TOTAL	SOLID FRACTION	LIQUID FRACTION	TOTAL
Iron	1579	306	1884	2776	444	3220	727	346	1074
Aluminum	448	210	658	526	508	1034	259	124	383
Chromium	42	14	56	41	9	50	48	33	81
Copper	34	7	41	42	9	51	20	6	26
Nickel	14	13	27	15	13	28	12	13	25
Lead	32	2	34	33	4	37	19	2	21
Zinc	94	29	123	123	*2901	*3024	57	55	112
Average of Metals	320	83	402	508	* 555	*1063	163	83	246

Notes:
i) Metals studies but not shown, were not present in quantities large enough to establish trends.
ii) All loadings in kg/day.
iii) * This average includes uncharacteristically high values recorded on April 21-22.
iv) These estimates are based on average values from individual sampling days and include extreme values measured on one or two days for most contaminants.

3.4.3 Effect of Design and Operational Characteristics of the WPCP

The behaviour of the various contaminants monitored during this study was expected to differ during treatment due to physical and chemical characteristics which affect how completely and by what mechanism they are removed.

Strier and Gallup (1982) stated that there are four basic removal pathways for organic compounds in any activated sludge type of waste treatment system; adsorption, volatilization/air stripping, biochemical and miscellaneous chemical reaction. Each specific organic compound will probably be strongly affected by only one of these removal mechanisms and to a much lesser extent by the remainder.

In most cases, aromatic compounds such as the PAHs and PCBs will be preferentially adsorbed. According to Strier and Gallup (1982) this is due to the PAHs low solubility in water which is especially prevalent in the higher molecular weight compounds (e.g. benzo(a)pyrene, pyrene and fluoranthene). The PAHs are relatively non-polar but have the capacity to polarize, therefore exemplifying the high polarizability - high adsorptivity relationship common to many trace organics. Due to their high adsorptivity the PAHs and PCBs would be expected to be removed to a large degree in the primary section of the treatment plant (Petrasek 1983). Thus primary clarifier loading rate is an important design parameter for removal of these organics.

In contrast to the behaviour of organic compounds, Brown (1973) found that metals have more efficiently removed in the secondary stages of sewage treatment plants. This operation is supported by Nelson (1981) who found that generally only 5 to 20% of the influent heavy metals mass was removed during primary clarification in his study.

Bridle (1980) suggests that the most important considerations in the design/operation of a biological treatment plant for control of hazardous contaminants are solids retention time (SRT) and hydraulic retention time (HRT). This points to the importance of the design and operation of the aeration section, including the final clarifiers and sludge wasting as key factors in HC removal efficiency.

Another important factor in the efficient treatment of trace metals is the regulation of pH within the system. According to Nelson (1981), pH is the single most important factor influencing metal adsorption onto both

organic and inorganic surfaces. However, he found that an average pH of 7 to 8 would provide satisfactory removal of most metals, and pH was not considered to be an important factor at the Hamilton WPCP since the average influent pH was within that range during the study.

In consideration of the foregoing discussion, key design and operational features of the Hamilton WPCP were assessed to determine the effects on HC removal during this study. These included:

i) SRT, HRT and Hydraulic Loading
ii) Primary versus secondary removals
iii) In-plant return stream loadings

3.4.3.1 Effect of SRT, HRT and Hydraulic Loading

A summary of the important factors SRT, HRT and final clarifier hydraulic loadings during the seasonal periods of the study is presented in Table 27 along with the average and ranges of removals achieved for the PAHs as a group, total PCBs and a group of seven metals monitored (iron, aluminum, chromium, copper, nickel, lead and zinc). Other metals were present in very low concentrations and were omitted from this assessment, as were lindane and PCP.

During the study, the SRT ranged from 2.9 days to 8.8 days with an overall average of 5.7 days. The winter, spring and summer average SRTs did not differ greatly, being 5.4, 4.9 and 6.7 days, respectively.

The average HRT in the aeration section of the plant varied somewhat throughout the study depending mainly on the aeration volume in service. The winter, spring and summer averages were 2.47, 3.14 and 3.74 hours, as more aeration volume was utilized during the summer period.

One of the most notable changes in the plant operation during the study was the balancing of flow between the old section and new section final clarifiers. As shown in Table 27 during the winter and spring periods, the old section clarifiers were hydraulically overloaded (23.8-48.9 $m^3/m^2 \cdot d$) compared to the new section clarifiers (9.3-24.6 $m^3/m^2 \cdot d$). During the summer a better flow split was achieved and the average hydraulic loadings were 17.6 $m^3/m^2 \cdot d$ in the new section and 23.8 $m^3/m^2 \cdot d$ in the old section.

TABLE 27. SUMMARY OF KEY DESIGN/OPERATIONAL PA[illegible]RSUS HC REMOVAL

	AVERAGE AERATION SYSTEM OPERATING CONDITIONS			SECO[illegible]Y CLARIFIERS HY[illegible]IC LOADING		[illegible]RALL PAH REMOVAL	OVER[illegible]PCB RE[illegible]L	OVERALL METAL REMOVAL
	HRT (h)	BOD LOADING ($g/m^3 \cdot h$)	SRT (days)	NEW SECTION AVG. HYDRAULIC LOADING ($m^3/m^2 \cdot d$)	OLD SECTION AVG. HYDRAULIC LOADING ($m^3/m^2 \cdot d$)	RANGE AVERAGE (%)	RANGE AVERAGE (%)	RANGE AVERAGE (%)
DECEMBER	2.06	33.0	3.57	11.0	48.9			
JANUARY	2.69	27.2	8.1	9.3	33.1	93 - 100	74 - 99	60 - 94
FEBRUARY	2.65	27.0	4.5	24.6	23.8			
WINTER AVERAGE	2.47	29.1	5.4	15.0	35.3	(98)	(88)	(86)
MARCH	2.9	26.1	2.9	19.5	26.9			
APRIL	3.17	14.2	6.3	16.0	31.7	87 - 100	99 - 100	71 - 96
MAY	3.36	17.6	5.6	21.9	25.8			
SPRING AVERAGE	3.14	19.3	4.9	19.1	28.1	(95)	(100)	(90)
JUNE	3.65	13.8	4.7	20.0	23.3			
JULY	3.83	7.3	6.5	17.4	22.2	94 - 100	71 - 100	52 - 97
AUGUST	3.75	11.1	8.8	15.4	25.8			
SUMMER AVERAGE	3.74	10.7	6.7	17.6	23.8	(98)	(88)	(81)
OVERALL AVERAGE	3.12	19.7	5.7	17.2	29.0	97	90	85
OVERALL MAXIMUM	3.83	33.0	8.8	24.6	48.9	100	100	97
OVERALL MINIMUM	2.06	7.3	2.9	9.3	22.2	87	71	52

In general, the aeration section was operating under both higher organic loading (BOD 29.1 g/m^3·h) and hydraulic loading during the winter period than during the spring or summer periods. The most favourable average conditions occurred during the summer period (highest HRT of 3.74 h; lowest BOD loading of 10.7 g/m^3·h; highest SRT of 6.7 days and lowest, most even loading to the final clarifiers).

Despite the significantly higher loadings and the imbalance between the old and new sections of the plant during the winter period, the overall treatment efficiency for the organics and metals studied did not differ significantly between the seasonal periods.

For example, the average removal for the group of PAHs was 98% in both the winter and summer periods. Similarly, for PCBs and metals there was no apparent correlation between the aeration section operating conditions and removals of the contaminants, as very good removals were achieved throughout the study (e.g. 88-100% PCB removals and 81-90% for the totalized group of seven metals).

These results support the findings of various EPA and Environment Canada studies, discussed by Melcer (1982), which generally acknowledged that SRT is one of the most important factors affecting the biological removal of priority pollutants. From the results of this study it is apparent that municipal WPCP's operating at 3-8 day SRTs, even at relatively low HRTs (2.5 to 4 h) and high organic loadings (30 g BOD/m^3·h) should achieve excellent removals of trace organics and metals.

3.4.3.2 Relative Removals by Primary and Secondary Treatment

Although the primary effluent was not analyzed for hazardous contaminants in this study, it has been found by EPA (1982) and others that a correlation exists between suspended solids removal efficiency in the primary clarifiers and trace organic and trace metal removals. Table 28 presents estimated HC removals for the primary and secondary sections of the WPCP, which were calculated based on the assumption that the solids fraction of the HCs would be removed in association with the suspended solids. In addition, it was necessary to assume that none of the dissolved fraction of the contaminants would be removed during primary treatment. Therefore, using the average primary suspended solids removal on sampling days during the study

TABLE 28. COMPARISON OF PRIMARY AND SECONDARY REMOVALS OF HAZARDOUS CONTAMINANTS

CONTAMINANT	TOTAL INFLUENT		SOLID FRACTION		[illegible] FRACTION		CALCULATED PERCENT CONTAMINANT REMOVAL IN PRIMARIES*	PRIMARY EFFLUENT		MEASURED FINAL EFFLUENT		CALCULATED PERCENT REMOVAL IN SECONDARIES	CALCULATED OVERALL PERCENT REMOVAL	MEASURED OVERALL PERCENT REMOVAL
	CONC'N (ug/L)†	MASS (kg/d)	CONC'N (ug/L)	MASS (kg/d)	CONC'N (ug/L)	MASS (kg/d)		CONC'N* (ug/L)	MASS* (kg/d)	CONC'N (ug/L)	MASS (kg/d)			
Naphthalene	15.2	4.4	11.0	3.2	4.2	1.3	44	8.5	2.5	0.3	0.08	54	98	97
Acenaphthylene	6.3	1.8	2.5	0.7	3.8	1.1	23	4.8	1.4	0.05	0.02	77	99	100
Dibenzofuran	12.2	3.5	6.4	1.9	5.8	1.7	32	8.3	2.4	0.14	0.04	67	99	95
Fluorene	16.1	4.7	9.4	2.7	6.7	1.9	35	10.4	3.1	0.22	0.06	63	98	97
Fluoranthene	44.0	12.6	35.9	10.3	8.1	2.3	50	22.1	6.3	0.7	0.2	49	99	96
Carbazole	22.3	6.5	8.6	2.5	13.7	4.0	24	17.1	5.0	0.4	0.11	75	99	98
Pyrene	39.8	11.5	33.4	9.6	6.4	1.9	51	19.4	5.6	0.9	0.26	46	97	95
Benzo(a)pyrene	44.7	13.2	35.0	10.3	9.7	2.9	48	23.4	6.9	0.7	0.21	51	99	99
PAH Average Removals							38					59	98	97
Total PCBs	0.131	0.04	0.084	0.03	0.047	0.01	41	0.077	0.022	0.025	0.01	40	81	90
Pentachlorophenol	0.23	0.07	0.02	0.004	0.21	0.006	5	0.218	0.06	0.1	0.03	51	56	63
Iron	6251	1817	4985	1464	1266	353	49	3210	924	478	135	44	94	93
Aluminum	1965	595	1310	401	655	194	41	1166	350	376	111	40	81	84
Chromium	192	58	133	40	58	17	43	110	33	18	5.5	48	91	91
Copper	129	39	105	32	25	7	49	66	19	20	6.0	36	84	89
Nickel	86	26	44	13	42	13	31	60	18	36	11	28	58	60
Lead	89	27	83	25	6	2	57	38	12	7	2	36	93	95
Zinc	431	131	281	86	150	45	40	260	79	91	27	39	79	81
Metal Average							44					39	83	85

* Calculated using average 61% SS removal in the primaries and assuming SS removal = removal of contaminant solids fraction.

(i.e. 61%) in combination with contaminant phase loading data, it was possible to calculate the resultant primary effluent HC masses and concentrations.

Comparison of the calculated primary effluent values to measured influent contaminant loadings allowed the estimation of percent removal efficiencies for the HCs in the primary clarifiers.

As can be seen in Table 28, the overall removal efficiencies calculated (e.g. 98% PAHs; 83% for the group of seven metals found in the greatest quantities) are very close to the measured values (97% for the PAHs; 85% for the metals), thus suggesting that the initial assumptions were valid.

Percent removals calculated for the PAHs in the primary clarifiers ranged from 24% for acenaphthylene and carbazole to approximately 50% for fluoranthene, pyrene and benzo(a)pyrene. The overall average removal of PAHs in the primaries was 38%. These results are slightly lower than results of the U.S. EPA MERL pilot plant study (EPA, 1982) in which it was found that 56% of the influent PAH loading was removed through primary treatment. The results in Table 30 are also lower than Petrasek's (1983) findings that up to 65% of the influent PAH mass may concentrate in the primary sludge. However, the PAH removal efficiencies estimated support the theory that the trace organics tend to absorb onto the solid fraction of the wastewater matrix, and thus to a large extent are settled out with the SS in the primary clarifiers.

Average removals of PCBs in the primaries was estimated to be 41% which was similar to the average of 50% Shannon (1976) found in his study of 33 municipal wastewater treatment plants in Ontario. Estimated PCP removal in the primary clarifiers was only 5% due to the very small mass associated with solid fraction of the wastewater.

The range for metal removal efficiencies in the primary clarifiers was similar to the trace organics (e.g. 31% for nickel to 57% for lead) due mainly to the wide range of solubilities and other characteristics of the metallic compounds studied. The average metal removal efficiency in the primaries calculated (44%) agreed well with the findings of Nomura (1974) reported that the percent removals of metals in the primary section of a municipal wastewater treatment plant ranged from 14% for nickel to 50% for copper, averaging 41% overall. Oliver and Cosgrove in their 1975 study found primary clarifier removals ranging from 15% for nickel to 69% for aluminum with an overall average of 57%.

In summary, the data in Table 28 suggests the following trends regarding primary versus secondary treatment efficiency for the HCs monitored.

i) PAHs tended to be removed to a greater degree in the secondary section (avg. = 59% compared to avg. = 38% in primaries).

ii) PCB removals in the primaries were estimated to be approximately equal to those in the aeration section.

iii) Trace metals removals appeared to be slightly higher in the primaries compared to the secondary section.

iv) Relative removals of specific contaminants in the primary and secondary sections of the plant appeared to vary mainly according to the influent concentration distribution between solids and liquid phases (i.e. individual contaminant characteristics). Both primary and secondary treatment processes were essential to achieve the efficient PCP removals of HCs observed in this study at the Hamilton WPCP (>85%-95% for most contaminants).

3.4.3.3 Effect of In-Plant Return Stream Loadings

During this study, the in-plant return stream was comprised of waste activated sludge, digester supernatant, vacuum filter filtrate, incinerator ash quench water, miscellaneous clean-up waters and periodic discharges resulting from digester clean out or aeration basin emptying. Sampling was limited to the combined influent, effluent, WAS (all sampling days) and the combined in-plant return stream, including WAS (on selected days only).

In order to assess the effect of in-plant return stream loadings on contaminant removal in the Hamilton WPCP, an extensive analysis was done to determine the relative contributions of raw municipal sewage, combined in-plant returns and the WAS return stream to the total combined influent.

A summary of the mass distributions for the PAHs monitored during this study is presented in Table 29. In addition to showing the relative percent of the total influent contaminant masses for each compound, Table 29 shows the breakdown of these masses between the liquid and solid phase of each source.

TABLE 29. MASS DISTRIBUTION OF PAHs BETWEEN COMBINED INFLUENT, HAMILTON RAW SEWAGE, TOTAL IN-PLANT RETURN AND WAS RETURN

CONTAMINANT	COMBINED INFLUENT				HAMILTON RAW SEWAGE					TOTAL IN-PLANT RETURN					WAS RETURN					
	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL INFLUENT	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL INFLUENT	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL RETURNS	% TOTAL INFLUENT
Naphthalene																				
Winter Average	0.388	0.001	0.389	98	0.3	0.0	0.3	100	77	0.088	T	0.089	99	23	0.001	0.000	0.001	100	1.1	0.3
Spring Average	0.355	2.302	2.657	13	0.3	2.3	2.6	12	98	0.055	0.002	0.057	99	2	0.000	T	T	--	--	--
Summer Average	0.113	2.602	2.715	4	0.1	2.6	2.7	4	99	0.013	0.002	0.015	87	1	0.018	0.001	0.019	100	100	1
Overall Average	0.4	1.201	1.60	25	0.3	1.2	1.5	20	94	0.061	0.001	0.062	99	6	0.005	T	0.005	100	8	0.3
Acenaphthylene																				
Winter Average	0.727	0.909	1.636	44	0.6	0.9	1.5	40	92	0.127	0.009	0.136	93	8	0.001	0.000	0.001	100	1	0.1
Spring Average	0.217	0.703	0.920	26	0.2	0.7	0.9	25	98	0.017	0.003	0.020	85	2	0.019	T	0.020	100	100	2.4
Summer Average	0.1	0.4	0.5	20	0.1	0.4	0.5	20	100	0.000	0.000	0.000	--	--	0.000	0.000	0.000	--	--	--
Overall Average	0.5	0.705	1.21	41	0.4	0.7	1.1	36	91	0.068	0.005	0.073	95	9	0.005	T	0.006	100	8	0.5
Dibenzofuran																				
Winter Average	0.824	0.521	1.345	61	0.6	0.5	1.1	55	82	0.224	0.021	0.245	91	18	0.003	0.000	0.003	100	1	0.2
Spring Average	0.169	0.307	0.476	29	0.1	0.3	0.4	20	87	0.069	0.007	0.076	91	13	0.029	T	0.029	100	38	5
Summer Average	0.207	0.504	0.711	29	0.2	0.5	0.7	29	98	0.007	0.004	0.011	64	2	0.000	0.000	0.000	--	--	--
Overall Average	0.5	0.513	1.01	50	0.4	0.5	0.9	44	89	0.131	0.013	0.145	88	11	0.008	T	0.008	100	1.5	0.8
Fluorene																				
Winter Average	1.014	0.734	1.748	58	0.7	0.7	1.4	50	80	0.314	0.034	0.349	90	20	0.002	0.000	0.002	100	0.6	0.1
Spring Average	0.337	0.305	0.642	52	0.3	0.3	0.6	50	93	0.037	0.005	0.042	88	7	0.018	T	0.019	100	45	3
Summer Average	0.209	0.205	0.515	41	0.2	0.3	0.5	40	97	0.009	0.005	0.015	60	3	0.000	0.000	0.000	--	--	--
Overall Average	0.7	0.52	1.22	57	0.5	0.5	1.0	50	82	0.169	0.020	0.188	90	18	0.006	T	0.006	100	3.2	0.5
Fluoranthene																				
Winter Average	4.242	0.652	4.794	88	2.1	0.6	2.6	81	54	2.142	0.052	2.194	98	46	0.114	T	0.114	100	5	2
Spring Average	1.647	0.309	1.956	84	1.2	0.3	1.5	80	77	0.447	0.009	0.456	98	23	0.281	0.000	0.281	100	62	14
Summer Average	0.791	0.305	1.096	79	0.6	0.3	0.9	75	80	0.191	0.005	0.196	98	20	0.117	0.000	0.117	100	60	12
Overall Average	2.7	0.429	3.19	86	1.5	0.4	1.9	79	61	1.231	0.029	1.260	98	39	0.157	T	0.157	100	13	5.0
Carbazole																				
Winter Average	1.778	1.434	3.212	55	1.3	1.4	2.7	48	84	0.478	0.034	0.512	93	16	0.086	0.000	0.086	100	17	3
Spring Average	2.861	3.210	6.071	47	2.1	3.2	5.3	40	87	0.761	0.010	0.771	99	13	0.615	T	0.616	100	80	10
Summer Average	1.159	5.210	6.369	18	0.9	5.2	6.1	15	96	0.259	0.010	0.269	96	4	0.271	0.000	0.271	100	100	4
Overall Average	1.9	2.822	4.72	40	1.4	2.8	4.2	33	89	0.494	0.022	0.516	96	11	0.265	T	0.265	100	51	5.6
Pyrene																				
Winter Average	3.818	0.538	4.357	88	1.2	0.5	1.7	71	39	2.618	0.038	2.657	99	61	0.152	T	0.152	100	6	4
Spring Average	1.706	0.312	2.018	85	1.1	0.3	1.4	79	69	0.606	0.012	0.618	98	31	0.423	0.000	0.423	100	68	21
Summer Average	0.703	0.305	1.008	70	0.5	0.3	0.8	63	79	0.203	0.005	0.208	98	21	0.126	0.000	0.126	100	61	13
Overall Average	2.5	0.423	2.92	86	1.0	0.4	1.4	71	48	1.511	0.023	1.535	98	52	0.213	T	0.213	100	14	7.3
Benzo(a)pyrene																				
Winter Average	10.09	4.320	14.409	70	7.6	4.1	11.7	65	81	2.490	0.220	2.709	92	19	0.055	0.000	0.055	100	2	0.4
Spring Average	7.257	2.334	9.591	76	5.7	2.2	7.9	72	82	1.557	0.134	1.691	92	18	0.746	0.000	0.746	100	44	8
Summer Average	2.911	2.03	4.940	59	2.4	2.0	4.4	45	89	0.511	0.030	0.540	95	11	0.129	0.000	0.129	100	24	3
Overall Average	7.6	3.251	10.85	70	5.8	3.1	8.9	65	82	1.76	0.151	1.912	92	18	0.246	T	0.246	100	13	2.3
Average of PAHs																				
Winter Average	2.86	0.61	3.47	70	1.8	1.08	2.88	64	74	1.06	0.058	1.11	95	26	0.052	0.00	0.052	100	6	1.6
Spring Average	1.82	1.22	3.04	52	1.4	1.2	2.6	47	86	0.44	0.023	0.47	94	14	0.266	T	0.27	100	55	6.6
Summer Average	0.77	1.45	2.22	38	0.63	1.45	2.06	36	92	0.149	0.008	0.163	96	8	0.082	0.0	0.082	100	43	4.1
Overall Average	2.0	1.23	3.3.	57	1.41	1.2	2.61	50	80	0.678	0.033	0.71	95	20	0.113	T	0.113	100	16	3.4

Notes: All loadings in kg/d

T = Trace

* Influent values in this table differ from those in Table 29 because data is from 14 days on Table 29 and 8 days this table (returns only sampled on 8 days).

Because of the extremely low concentrations of lindane, PCBs and PCP, particularly in the return streams, accurate estimates for these compounds could not be developed. It is noted however, that traces of PCB and PCP were detected in the in-plant return and WAS return, whereas no lindane was found in the return streams.

With regard to the PAHs, a combined average of 80% of the mass was from the Hamilton sewage (50% associated with the solids on average), meaning that as an overall average, 20% of the PAHs monitored came from the in-plant return stream. This varied from a low of 8% in the summer period when combined influent PAH loadings were lower, to a high of 26% in the winter. The contribution of PAHs in the in-plant return stream to the combined influent loading, ranged from a low of 6% for naphthalene to a high of 52% for pyrene. Although there was considerable variability among sampling dates and seasonal averages, there appeared to be a trend toward greater contributions of PAHs from the in-plant return stream during the winter period. Because there are so few data points and so many interrelated factors involved, further study is required to verify this apparent trend and the reasons for it.

It is important to note that the seasonal average percentages of PAHs in the in-plant return solids fraction was consistently high for all compounds (i.e. 88-99%, with an overall average of 95%). The solid fraction of the WAS return stream accounted for essentially 100% of the WAS stream organics because extremely low concentrations were measured in the liquid phase. On the other hand, there was considerable variability in the amount of each PAH associated with the solids fraction of the Hamilton sewage. The general trend observed was that for contaminants which tended to be concentrated in the solids fraction in all samples, a relatively high percentage of the total contaminant loading came from the in-plant return stream (e.g. fluorene - 18%; fluoranthene - 39%; pyrene - 52%; and benzo(a)pyrene - 18%), and for these compounds the contribution from the WAS return was also higher (e.g. fluoranthene averaged 5% of total influent mass; carbazole 5.6%; pyrene 7.3%). Again, there was a large variation in the contributions of specific PAHs in the WAS to the total in-plant return and total influent; however, there was consistently lower loadings of PAHs in the WAS during the winter (e.g. average of PAHs was 6% of total returns in the winter compared to 55%

and 43% in the spring and summer). This may be reflecting a poorer adsorption of PAHs onto the WAS during the winter which would point to biodegradation as an important PAH removal mechanism (since equally good removals of PAHs were achieved in the winter). However, further research is required to verify this trend and to assess removal mechanisms.

Since the contaminant contribution of the WAS stream to the in-plant return stream was relatively small for most of the organics monitored (averaging 3%-14% for all but carbazole at 51%), it is apparent that other streams making up the total in-plant return were making significant contributions to the total influent loading. This observation, and a review of the results of a study by CANVIRO (1984) in which the fate of PAHs and metals during anaerobic digestions was investigated, point to the digester supernatant as a major source of some PAHs. For example, the two PAHs with the greatest contribution from the in-plant returns in this study were fluoranthene and pyrene. In the CANVIRO (1984) study, fluoranthene and pyrene solubilized to the greatest extent during digestion (approximately 300% for both), and these two compounds were present in the raw Hamilton digester sludge in concentrations higher than any of the other PAHs monitored in that study (6-10 mg/L average).

Table 30 provides comparisons of the mass distributions within the plant for the trace metals group. The elements arsenic, cadmium, mercury and selenium were not present in the influent or return streams in concentrations large enough to provide any meaningful results or to establish any trends. Thus, discussion of the metals distribution is limited to 7 of the metals (Fe, Al, Cr, Cu, Ni, Pb, Zn).

Trace metal loadings in the solid fraction of the combined influent ranged from an overall average of 2040 kg/d for iron to 13.5 kg/d for nickel. Average liquid fraction loadings for the combined influent varied from an overall average of 442 kg/d for iron to approximately 3.0 kg/d for lead. Lower loadings were observed for metals during the summer. Trends in metal loadings for the combined influent indicate that as an overall average approximately 73% of the total mass was contained in the solid fraction of the wastewater. This is consistent with Kang's (1981) assertion that the majority of metallic contaminants present in a sewage treatment plant will exist in a solid form because of the relative insolubility of the metals.

TABLE 30. MASS DISTRIBUTION OF TRACE METALS BETWEEN COMBINED INFLUENT, HAMILTON RAW SEWAGE, TOTAL IN-PLANT RETURN AND WAS RETURN

CONTAMINANT	COMBINED INFLUENT				HAMILTON RAW SEWAGE					TOTAL IN-PLANT RETURN					WAS RETURN					
	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL INFLUENT	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL INFLUENT	SOLID FRAC.	LIQ. FRAC.	TOTAL	% IN SOLID	% TOTAL RETURNS	% TOTAL INFLUENT
Iron																				
Winter Average	2368	459	2827	82	1838	424	2262	81	80	530	35	564	94	20	129	0.2	129.2	100	23	4.6
Spring Average	2778	346	3124	89	2054	322	2376	86	76	724	24	748	97	24	369	2.4	369.2	100	49	11.8
Summer Average	646	505	1151	56	466	487	953	49	83	180	18	198	91	17	189	2.4	191.4	99	97	16.6
Overall Average	2040	442	2482	82	1549	414	1963	79	79	491	28	519	95	21	204	0.8	204.8	100	39	8
Aluminum																				
Winter Average	484	275	759	64	350	270	620	56	82	134	5.1	139.1	96	18	12.4	0.3	12.7	99	9	1.6
Spring Average	578	101	679	85	365	96	461	79	68	213	4.8	217.8	98	32	121.7	0.5	122.2	99	56	17.9
Summer Average	177	145	322	55	132	142	274	48	85	45	2.8	47.8	94	15	47.7	1.6	49.3	99	100	15
Overall Average	431	198.5	629	69	299	194	493	61	78	131	4.5	135.5	97	22	48.6	0.6	49.2	99	36	7.8
Chromium																				
Winter Average	45.3	12.3	57.6	79	29.9	11.5	41.4	72	72	15.4	0.8	16.2	95	28	3.7	T	3.7	100	23	6.4
Spring Average	38.2	7.8	46.0	83	19.3	7.3	26.7	72	58	18.9	0.5	19.4	97	42	9.7	0.0	9.7	100	50	21
Summer Average	49.7	46.5	96.2	52	42.7	46.1	88.8	48	92	17.0	0.4	17.4	95	8	7.5	0.1	7.6	99	44	7.9
Overall Average	44.6	19.7	64	70	30.4	19.1	49.5	61	77	14.2	0.6	14.8	96	23	6.1	T	6.2	99	42	10
Copper																				
Winter Average	36.4	9.2	45.6	80	27.1	8.8	35.9	75	79	9.3	0.4	9.7	96	21	2.1	T	2.2	96	23	5
Spring Average	48.5	11.7	61.2	79	34.1	11.5	45.7	75	75	14.4	0.2	14.6	99	24	8.6	T	8.7	99	60	14
Summer Average	11.1	5.4	16.5	67	8.3	5.4	13.7	61	83	2.8	T	2.9	97	18	2.8	T	2.9	97	100	18
Overall Average	33.1	8.9	42	79	24.1	8.6	32.7	74	78	9.0	0.3	9.3	97	22	3.9	T	4.0	98	43	9
Nickel																				
Winter Average	17.8	15.4	33.2	54	14.3	14.9	29.2	49	88	3.5	0.5	4.0	88	12	0.9	T	0.9	100	23	2.7
Spring Average	13.1	16.1	29.2	45	8.5	15.7	24.2	35	83	4.6	0.4	5.0	92	17	2.8	T	2.9	97	58	10
Summer Average	5.3	16.3	21.6	25	4.0	15.9	19.9	21	92	1.3	0.4	1.7	76	8	1.4	0.1	1.5	94	88	6.9
Overall Average	13.9	15.7	29.2	46	10.3	15.3	25.6	40	88	3.2	0.4	3.6	89	12	1.5	T	1.6	94	44	5
Lead																				
Winter Average	27.2	2.4	29.6	92	20.2	2.0	22.2	91	75	7.0	0.4	7.4	95	25	1.1	T	1.1	100	15	3.7
Spring Average	31.5	7.0	38.5	82	22.2	6.9	29.1	76	76	9.3	0.1	9.4	99	24	5.1	T	5.1	100	54	13
Summer Average	9.4	0.0	9.4	100	6.4	0.0	6.4	100	68	3.0	0.0	3.0	100	32	2.4	0.0	2.4	100	80	26
Overall Average	23.8	2.98	26.7	89	17.2	2.7	19.9	86	75	6.6	0.2	6.8	97	25	2.4	T	2.4	100	35	9
Zinc																				
Winter Average	89.9	31.4	121.6	74	56.7	30.4	87.1	65	72	33.2	1.4	34.6	99	28	6.3	T	6.4	98	18	5
Spring Average	106.6	30.2	136.9	78	56.9	29.7	86.1	66	63	50.2	0.5	50.7	99	37	24.3	0.1	24.4	99	48	18
Summer Average	37.5	64.0	101.6	37	26.2	63.4	89.6	29	88	11.3	0.6	11.9	95	12	9.1	0.3	9.4	97	79	9
Overall Average	81	39.9	120.5	73	49.0	38.9	87.5	56	73	32.0	1.0	33.0	97	27	11.9	0.1	11.6	99	35	10
Average of 7 Metals																				
Winter Average	438	115	553	79	334	109	443	75	80	105	6.2	111.2	94	20	22.2	0.08	22.3	99	20	4.0
Spring Average	511	74	585	87	320	69.8	390	82	67	148	4.4	152.4	97	26	77.3	0.11	77.4	99	51	13.2
Summer Average	141	112	253	56	86	109	195	44	77	36	3.2	39.2	92	15	35.1	0.64	35.7	98	91	14.1
Overall Average	380.0	103.4	483.4	73	282.7	123.4	381.5	65	79	98.1	5.0	103.1	95	21	39.7	0.2	39.9	99	39	8.2

Notes: All loadings in kg/d

T = Trace

* Influent values in this table differ from those in Table 26 because data is from 14 days on Table 26 and 8 days this table (returns only sampled on 8 days).

The results in Table 30 show the Hamilton sewage input as contributing approximately 79% of the overall metals loading to the plant. Thus, an overall average of 21% of the total metals mass entering the plant resulted from the in-plant returns. Unlike the organics there was little difference in the percent contribution of the in-plant return from metal to metal, with the exception of the more soluble nickel (averaging 12% from the in-plant return). Within the total return stream the metals were consistently associated mainly with the solids fraction (i.e. 89-97% for the 7 metals; average 95%). Mass loadings in the solids fraction of the total in-plant return ranged from 3.2 kg for nickel to 491 kg for iron, while in the liquid phase, values were from 0.2 kg for lead to 28 kg for iron.

A review of the seasonal average results, although not conclusive, showed a trend toward higher percentages of metals in the total in-plant return during the winter and spring months. For example, loadings for Fe and Al in the in-plant returns peaked in the winter months, while Cr, Cu, Ni, Pb and Zn concentrations were greatest in the spring. Further study is required to verify this trend and further identify the sources of contaminants within the total in-plant return stream.

The WAS contribution of heavy metals to the total return flow was substantially greater than for organics. As an overall average, 39% of the return metals mass was contained in the waste activated sludge. On an overall average basis, this trend was consistent from metal to metal during the study as indicated by the range of 35%-44% of various metals coming from the in-plant return. However, on a seasonal basis there was a trend toward lower masses and lower percent contributions of metals from the WAS stream during the winter. As discussed, this trend was also noted for the PAHs.

The WAS return stream also made a significant contribution to the metals loading in the combined influent, as it made up 8% of the total metal mass as an overall average. Similar to the trace organics, the trace metals concentrated almost exclusively in the solid fraction of the WAS with less than 0.5% of the metal load being attributable to the liquid fraction.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The following conclusions relating to the removal of hazardous contaminants in the Hamilton WPCP can be drawn from this study.

1) Concentrations of contaminants entering the Hamilton WPCP were within the ranges found in previous U.S. EPA and Environment Canada studies of municipal treatment plants serving industrialized areas.
2) Results indicate a high degree of overall removal (>97% for the WPCP as a whole) for the PAHs. Total PCBs were similarly well removed, averaging 90%. Both lindane and pentachlorophenol were removed to a lesser extent (70% and 63%, respectively) and with considerably less consistency. Trace metals removals were generally in excess of 80% (overall average = 85%, ranging from 62% for nickel to 95% for lead).
3) Annual loadings of HCs entering and being discharged from the Hamilton WPCP were estimated as follows:

HAZARDOUS CONTAMINANT	ANNUAL LOADING (kg/yr) *					
	INFLUENT			EFFLUENT		
TRACE ORGANICS	SOLID FRACTION	LIQUID FRACTION	TOTAL	SOLID FRACTION	LIQUID FRACTION	TOTAL
Naphthalene	1,004	427	1,431	1.1	29.2	30.3
Acenaphthylene	241	372	613	0.4	3.7	4.1
Dibenzofuran	606	544	1,150	1.4	11.0	12.4
Fluorene	887	639	1,526	0.7	18.3	19.0
Fluoranthene	3,325	741	4,066	54.8	11.0	65.7
Carbazole	924	1,383	2,310	36.5	7.3	43.8
Pyrene	3,110	595	3,705	73.0	11.0	84.0
Benzo(a)pyrene	3,457	960	4,420	65.7	3.7	69.4
Lindane	0.0	7.3	7.3	0.0	3.7	3.7
Total PCBs	11.0	3.7	14.7	1.1	2.9	4.0
Pentachlorophenol	1.5	21.9	23.4	0.0	11.0	11.0
TRACE METALS						
Iron	612,105	130,305	742,410	26,061	24,966	51,027
Aluminum	151,840	98,915	250,755	8,724	30,587	39,311
Arsenic	219	0	219	14	0	14
Cadmium	110	0	110	11	0	11
Chromium	15,951	67,160	83,111	1,095	913	2,008
Copper	11,826	2,665	14,491	712	1,314	2,026
Mercury	21.9	7.3	29.2	1.1	2.6	3
Nickel	5,074	4,782	9,892	237	3,723	3,979
Lead	9,782	803	10,585	475	219	694
Selenium	168	0	183	33	0	33
Zinc	33,580	312,805	346,385	2,482	7,556	10,038

* These estimates are based on average values from 14 sampling days and include very high values measured on one or two days for most contaminants. Thus, these annual averages are considered to be high estimates.

Note: Percent removals calculated using averaged concentrations (Appendix B) and averaged annual loadings (above Table) do not correspond exactly because of mathematical rounding and analytical capabilities, especially for contaminants at or near their detection limit.

4) Despite experiencing significantly higher loadings and poorly balanced loadings between the old and new sections of the plant during the winter and spring periods, the overall treatment efficiency for the organics and metals studied did not differ significantly between the seasonal periods (e.g. winter and summer average PAH removals were both 98%; 88 to 100% for PCBs; 81 to 90% for totalized metals).

5) From the results of this study, it is apparent that municipal WPCP's operating at 3-8 days SRTs, even at relatively low HRTs (2.5 to 4 h) and high organic loadings (30 g BOD/m^3·h) can achieve excellent removals of trace organics and metals. This supports the belief that SRT is one of the most important factors affecting biological removal of priority pollutants.

6) The following trends were indicated regarding primary versus secondary treatment efficiency for the HCs monitored:
   i) PAHs tended to be removed to a greater degree in the secondary section (average = 59% compared to average = 38% in primaries).
   ii) PCB removals in the primaries were estimated to be approximately equal to those in the aeration section.
   iii) Trace metals removals in the primaries were slightly higher than in the aeration section.
   iv) Relative removals of specific contaminants in the primary and secondary sections of the plant appeared to vary mainly according to the influent concentration distribution between solid and liquid phases (i.e. individual contaminant characteristics). Both primary and secondary treatment processes were essential to achieve the efficient removals of HCs observed in this study at the Hamilton WPCP.

7) Assessment of the contaminant loadings originating from the raw Hamilton sewage, the total in-plant return stream (including WAS) and the WAS return stream showed that as an overall average of all the HCs monitored, approximately 20% of the loading originated from the in-plant return stream. This varied considerably between specific contaminants, being less than 10% for some PAHs, 52% for pyrene, 12% for nickel and 20-25% for the other metals.

8) The WAS return stream contributed overall averages of 14% and 39% to the total in-plant return PAHs and metals loadings, respectively. Thus, the WAS return represented on average 3% and 8% of the total influent loadings of PAHs and metals, respectively. Only trace amounts of PCBs and pesticides were detected in the return stream.

9) The percentage of metals and organics loadings from the total in-plant return stream appeared to be lower in the summer. On the other hand, it was noted that despite this, the relative contributions by the WAS stream were highest in the summer for all but the most volatile PAHs (e.g. acenaphthylene).

10) It was found that both the organics and metals in the total in-plant return stream were consistently associated almost exclusively with the solids fraction (>95% average). This was in contrast to the wide range of percentages found in the raw sewage (e.g. 20%-79% for PAHs and 40%-86% for metals).

11) Since only 14% of the PAHs and 39% of the metals in the total in-plant return were accounted for by the WAS return stream, it is apparent that other in-plant returns such as digester supernatant and vacuum filter return must be contributing significant quantities of contaminants to the combined WPCP influent loadings.

12) The trends observed, although not conclusive, support the conclusion that a combination of adsorption, biodegradation and volatilization mechanisms play a role in removal of HCs at the Hamilton WPCP.

4.2 Recommendations

Recommendations relating to the operation of the Hamilton WPCP include:

1. Continued efforts should be made to maintain an even balance of loading between the old and new sections of the plant.
2. The plant should be operated at a minimum 5 day SRT to maximize removal of HCs entering the plant.
3. SRT control should be practiced separately on the old and new sections.

4. Action should be considered to minimize the suspended solids content of the in-plant return streams (other than WAS) since over 95% of the contaminants in the total in-plant return were associated with the solids fraction.
5. Industrial sources of the shock loads of certain contaminants, particularly zinc should be identified and eliminated since occasional daily average concentrations observed in this study were in the range known to be inhibitory to the activated sludge process.

Recommendations for further research arising from this study include:

1. Investigations should be carried out to verify the percent contributions of the various in-plant return streams, as approximately 80% of the PAHs and 60% of the metals in the total return stream are not accounted for by the WAS return.
2. Since overall seasonal and other trends were difficult to establish because of the limited number of samples collected in this study, the methodology should be utilized under more controlled conditions, such as sampling on days when certain known events are occurring rather than on randomly selected days.
3. Emphasis should be placed in future studies on the factors affecting primary treatment efficiency and on sludge handling process factors contributing to the trace organics and metals removals/recycle within municipal WPCP's.

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APPENDIX A

PHASE 1 - CLEAN-UP EXPERIMENTS AND RESULTS

APPENDIX A - PHASE 1 CLEAN-UP EXPERIMENTS

The trace organic compounds selected for monitoring at the Hamilton WPCP are listed below:

1,4-dichlorobenzene
naphthalene
acenaphthylene
2,6-dinitrotoluene
dibenzofuran
fluorene
carbazole
fluoranthene
pyrene
benzo(a)pyrene

The purpose of the clean-up experiments was to determine whether three of the compounds; i.e. 1,4-dichlorobenzene, naphthalene and 2,6-dinitrotoluene could be adequately recovered from an existing clean-up procedure currently in use at CANVIRO. Experience with this procedure during another study (CANVIRO 1984) had already demonstrated that the other seven compounds were satisfactorily recovered using this procedure.

The clean-up is based on liquid column chromatography using a glass column (40 cm x 2 cm) packed with silica gel (20 gm of 3% deactivated gel, 100-200 mesh size, grade 923). The packed column is operated under gravity flow at a flow rate of 3(±) 1 mL/min. Three fractions are obtained:

FRACTION #	ELUTION SOLVENT	TYPE OF COMPOUNDS ELUTED
F_1	90 mLs Hexane	Mainly Non-Polar
F_2	90 mLs 50% Hexane in dichloromethane	Mainly Semi-Polar
F_3	90 mLs 5% Acetone in dichloromethane	Mainly Polar

The seven compounds elute in F_2 with good recoveries; i.e. better than 70%. Therefore, it is customary at CANVIRO to collect F_2 only; F_1 is discarded since it normally contains the bulk of non-polar interferences. Polar interferences remain on the column and F_3 is only collected when a polar fraction is required.

In the following experiments it was necessary to determine whether the three compounds could be recovered in F_2 or whether portions of F_1 and F_3 would also have to be collected. In addition, it was necessary to determine whether the fractions collected could be combined and analyzed by GC as a single sample without decreasing the effectiveness of the clean-up or whether each fraction would have to be analyzed separately.

Two calibration standards were made, one in iso-octane and one in dichloromethane. This was necessary because of the differences in techniques used for applying extracts of solid and liquid samples to the clean-up column (see Section 2.2.3.2).

Experiment 1

Two clean-up columns were prepared and calibration runs were performed using the 2 calibration solutions. The three fractions were collected, concentrated and analyzed by high resolution GC-FID. Recoveries of the 10 compounds were calculated.

Results of Experiment 1

The recoveries of the compounds are given in Table A-1.

TABLE A-1. RECOVERY OF COMPOUNDS IN CLEAN-UP EXPERIMENT 1

COMPOUND	RECOVERY (%)							
	ISO-OCTANE SOLUTION				DICHLOROMETHANE SOLUTION			
	F_1	F_2	F_3	TOTAL	F_1	F_2	F_3	TOTAL
1,4-dichlorobenzene	54			54				0
Naphthalene	7	62		69		65		65
Acenaphthylene		82		82		88		88
2,6-dinitrotoluene		55	28	83		36	50	86
Dibenzofuran		84		84		90		90
Fluorene		89		89		95		95
Carbazole		84		84		89		89
Fluoranthene		90		90		98		98
Pyrene		90		90		97		97
Benzo(a)pyrene		88		88		93		93

As shown in Table A-1, only 54% of 1,4-dichlorobenzene in the iso-octane solution was recovered in F_1; naphthalene was recovered in both F_1 (7%) and F_2 (62%). 2,6-dinitrotoluene was recovered in F_2 (55%) and F_3 (28%). In contrast, none of the 1,4-dichlorobenzene in the dichloromethane solution was recovered; naphthalene was recovered in F_2 only (65%) and 2,6-dinitrotoluene was recovered in F_2 (36%) and F_3 (50%).

Because of the differences between these two runs, the experiment was repeated.

Experiment 2

Results of Experiment 2

The data is shown in Table A-2.

TABLE A-2. RECOVERY OF COMPOUNDS IN CLEAN-UP EXPERIMENT 2

COMPOUND	RECOVERY (%)							
	ISO-OCTANE SOLUTION				DICHLOROMETHANE SOLUTION			
	F_1	F_2	F_3	TOTAL	F_1	F_2	F_3	TOTAL
1,4-dichlorobenzene	60			60	47			47
Naphthalene	8	78		86	5	67		72
Acenaphthylene		99		99		93		93
2,6-dinitrotoluene		58	40	98		32	57	89
Dibenzofuran		104		104		99		99
Fluorene		108		108		102		102
Carbazole		111		111		104		104
Fluoranthene		110		110		108		108
Pyrene		110		110		110		110
Benzo(a)pyrene		104		104		106		106

The results showed much better agreement between the two runs.

Experiment 3

Experiment 2 demonstrated reasonable consistency in the operation and performance of the clean-up procedure. Therefore, in experiment three collection of the fractions was modified as shown below:

ORIGINAL FRACTION #	VOLUME OF ELUTION SOLVENT	NEW FRACTION #	VOLUME OF ELUTION SOLVENT
F_1	hexane 90 mLs	f_1	30 mLs
		f_2	30 mLs
		f_3	30 mLs
F_2	50-50 hexane and dichloromethane 90 mLs	f_4	90 mLs
F_3	5% acetone in dichloromethane 90 mLs	f_5	30 mLs
		f_6	30 mLs
		f_7	30 mLs

Two calibration runs were performed and 7 fractions were collected and analyzed for each run.

Results of Experiment 3

The recoveries are shown in Tables A-3.1 and A-3.2.

TABLE A-3.1. RECOVERY OF COMPOUNDS IN THE ISO-OCTANE SOLUTION

COMPOUND	RECOVERY (%)							
	F_1			F_2	F_3			TOTAL
	f_1	f_2	f_3	f_4	f_5	f_6	f_7	
1,4-dichlorobenzene		46						46
Naphthalene			8	76				84
Acenaphthylene				97				97
2,6-dinitrotoluene				51	40			91
Dibenzofuran				100				100
Fluorene				103				103
Carbazole				104				104
Fluoranthene				106				106
Pyrene				106				106
Benzo(a)pyrene				102				106

TABLE A-3.2. RECOVERY OF COMPOUNDS IN THE DICHLOROMETHANE SOLUTION

COMPOUND	RECOVERY (%)							
	F_1			F_2	F_3			TOTAL
	f_1	f_2	f_3	f_4	f_5	f_6	f_7	
1,4-dichlorobenzene		50						50
Naphthalene				69				69
Acenaphthylene				86				86
2,6-dinitrotoluene				13	73			86
Dibenzofuran				88				88
Fluorene				91				91
Carbazole				88				88
Fluoranthene				94				94
Pyrene				94				94
Benzo(a)pyrene				90				90

As shown in Table A-3.1, naphthalene was recovered both in f_3 (8%) and f_4 (76%); 2,6-dinitrotoluene was recovered in f_4 (51%) and f_5 (40%). As shown in Table A-3.2, naphthalene was recovered in f_4 only (69%) and 2,6-dinitrotoluene was recovered in f_4 (13%) and f_5 (73%). 1,4-dichlorobenzene recoveries were more consistent for the 2 runs, 46% (Table A-3.1) and 50% (Table A-3.2).

The results of this experiment suggested that in order to recover the 3 compounds: 1,4-dichlorobenzene, naphthalene and 2,6-dinitrotoluene, the following elution scheme would be required:

ELUTION SOLVENT	FRACTIONS TO COLLECT	REVISED FRACTION #
90 mLs hexane	Discard 1st 30 mLs Collect final 60 mLs	F_1
90 mLs 50-50 hexane and dichloromethane	Collect 90 mLs	F_2
90 mLs 5% acetone in dichloromethane	Collect 1st 30 mLs	F_3

Conclusions

The experiments provided the following information:

i) Portions of F_1 and F_3 must be collected in order to recover all three additional compounds, ie. 1,4 dichlorobenzene, naphthalene, and 2,6-dinitrotoluene. However, naphthalene was usually recovered satisfactorily.

ii) A revised elution scheme was determined.

iii) Recoveries for the more volatile compounds such as 1,4-dichlorobenzene tended to be more variable and sometimes rather low.

iv) Additional experiments involving extracts of sewage samples would be necessary in order to determine whether or not the fractions collected could be combined and analyzed by GC as a single sample without reducing the effectiveness of the clean-up.

Recommendations

It was recommended that further work be performed in order to optimize the clean-up procedure for all ten compounds. Otherwise, 1,4-dichlorobenzene and 2,6-dinitrotoluene should be dropped from the list of selected trace organics to be monitored at the Hamilton WPCP.

APPENDIX B

QA/QC RESULTS AND PHASE 1/PHASE 2 ANALYTICAL DATA

APPENDIX B

SUMMARY OF QA/QC RESULTS AND PHASE 1 AND PHASE 2 ANALYTICAL DATA

In this section the following data sets are presented:

Phase 1

- Results of GC analysis for PAH group for solid fractions (Table B-1 and B-3) and liquid fractions (B-2 and B-4).
- Summary of compound recoveries for PAH group for solid and liquid fractions (B-5).
- Comparison of GC-FID and GC-MS results obtained for PAH group (B-6).

Phase 2

- Results of GC analyses for PAH group (B-7 to B-16).
- Summary of analytical precision obtained for PAH group for solid fractions (B-17) and liquid fractions (B-18).
- Summary of compound recoveries for PAH group for solid fractions (B-19) and liquid fractions (B-20).
- Comparison of GC-FID and GC-MS results obtained for PAH group (B-21).
- Results of PCB and pesticide analyses for solid and liquid fractions in WPCP influent and effluent (B-22).
- Results of Lindane, Total PCB and PCP analyses for solid and liquid fractions in WPCP in-plant return (B-23).
- Results of metals analyses for solid and liquid fractions in WPCP influent and effluent (B-24).
- Results of metals analyses for solid and liquid fractions in WPCP in-plant return (B-25).
- Influent and effluent PAH levels (B-26 to B-33).
- Influent and effluent PCB and Pesticide levels (B34 to B36).
- Influent and effluent metal levels (B37 to B49).

QA/QC Results for PAH Group

Phase 1

In addition to providing an opportunity for verification of sampling and sample handling techniques, Phase 1 provided for some methods development and thorough QA/QC for the PAH group. Phase 1 results are presented in Tables B-1 to B-6. For both sampling occasions in Phase 1, PAH concentrations in the influent were generally low; i.e. less than 50 ug/g in the solid fraction and less than 11 ug/L in the liquid fraction. In the effluent, compounds were generally present only in traces, except in the case of higher boiling compounds which were present in the solid fraction at concentrations up to 30 ug/g.

Analytical precision (Tables B-1 to B-4) was generally good with relative standard deviations (RSDs) typically better than 35% for triplicate determinations. There were some exceptions in cases where concentrations were very close to the detection limits (i.e. 1 ug/g for solid fraction and 1 ug/L for liquid fraction).

Analytical accuracy was monitored by spiking duplicate samples at two concentrations with a cocktail of the ten compounds (PAH group including 1,4-dichlorobenzene and 2,6-dinitrotoluene). Each compound was present in the cocktail at a concentration of 50 ug/mL and one on two mLs of the solution was spiked into the samples. A summary of the compound recoveries obtained in Phase 1 are presented in Table B-5.

1,4-dichlorobenzene was not recovered in any of the samples and the recovery of 2,6-dinitrotoluene was very poor and variable with a mean and standard deviation of 5% ± 5 for the solid fraction and 8% ± 11 for the liquid fraction.

The remaining eight compounds (PAH group) were generally recovered reasonably well; i.e. 50-100% except in the case of naphthalene and acenaphthylene. Recovery was better from the liquid fraction than from the solid fraction and it was higher for compounds with higher boiling points. This was particularly clear for the solid fraction and compound losses for this fraction were undoubtedly worse because of the spiking technique used. As discussed in Section 2.2.6, the spike solution was added to the sample and the solvent was allowed to evaporate a room temperature overnight in a fumehood prior to soxhlet extraction. Naphthalene readily sublimes even at room

temperature and therefore it would tend to be lost to atmosphere with the solvent. The other lower boiling compounds such as acenaphthylene would be lost to some extent as well.

In addition to the replicates and spiked samples, distilled water blanks were included at every stage of the analytical protocol. Both blanks and spikes were extracted, cleaned-up and analyzed along-side the other samples. Contamination was not found to be a problem even in the measurement of very trace level of these compounds, however, care was required to maintain the GC autosampler injection system in a clean condition prior to the performance of low level work.

Qualitative and quantitative accuracy was monitored by confirmatory GC-MS analyses. Extracts analyzed by GC-FID were submitted to the Wastewater Technology Centre (WTC) in Burlington for this work. Table B-6 provides a comparison of the GC-FID and GC-MS data obtained for each sample.

Since the WTC does not routinely analyze for carbazole and dibenzofuran, CANVIRO was unable to obtain confirmatory GC-MS results for these two compounds. However, in view of the fact that good agreement between the two techniques was usually obtained for the other six compounds, it seems reasonable to assume that GC-FID data for carbazole and dibenzofuran was also satisfactory.

The most notable discrepancies between GC-FID and GC-MS results were for the later eluting compounds - particularly benzo(a)pyrene in extracts of solid fractions. In spite of prior clean-up, these extracts usually generated complex chromotograms with many peaks. Identification and quantitation by GC-FID was most difficult for benzo(a)pyrene because of closely eluting adjacent peaks and a sloping baseline.

For the most part, GC-MS should give more reliable analyses than GC-FID, both qualitatively and quantitatively. Mass spectral data provides increased qualitative confidence, and hence reduces the chance of false positive identifications compared to GC-FID. In addition, the facility for selected ion monitoring, allows improved quantitation by reducing the effect of interferences.

Typically, when discrepancies occur the GC-FID tends to give higher results than the GC-MS for such reasons as:

i) a peak was incorrectly identified by GC-FID,
ii) occurrence of a mixed peak such as when an interferent co-elutes with a compound of interest, and
iii) the presence of interferences which chromotograph in such a way so as to generate a spiked and sloping baseline.

Phase 2

Analytical precision, accuracy and background contamination were monitored during Phase 2 of the study. The results have been summarized for precision (Tables B-17 and B-18), compound recoveries (Tables B-19 and B-20) and GC/GC-MS comparison (Table B-21).

Analytical precision was generally very good for both solid and liquid fractions. RSDs for 87% of the duplicates were <20% of the mean concentration. The level of precision wa the same for all eight compounds monitored at the WPCP.

Analytical accuracy as determined by compound recoveries was improved during Phase 2 compared to Phase 1 for both solid and liquid fractions. Recoveries ranged from 65-91% for solid fractions and from 79-106% for liquid fractions. In part, this was the result of improved techniques for manipulation of extracts at various stages of extraction and clean-up. Also, a single analyst performed most of the extract preparation during Phase 1, whereas several analysts were involved in the work of Phase 2.

For extracts of solids, the improvement in the recovery of the lower boiling compounds was obtained because the spiking procedure for this fraction was changed (Section 2.2.6). Spiking was done directly into the sample at the start of the soxhlet extraction. Whilst this avoids compound losses due to evaporation with the solvent, it does not provide any information on the "true recoverability" of these compounds from the solid matrix. If should be noted that the other technique used in Phase 1 also suffered from this deficiency. Clearly, a distinction can be made between the strictly "analytical recovery data" (i.e. losses due to sample handling during

extraction and clean-up) obtained in Phase 2 and the "true recoverability" of compounds from the sample matrix that might be obtained by using some alternative spiking technique. This experience has shown that new spiking protocols need to be devised and evaluated.

Qualitative and quantitative accuracy was monitored by confirmatory GC-MS analyses. Extracts analysed by GC-FID were submitted to the MOE for this work. Table B-21 provides a summary of the GC-FID and GC-MS data obtained for each type of sample extract.

Results were similar to those obtained during Phase 1. Generally, the agreement between the two sets of data was good. Notable exceptions usually involved the later eluting compounds (i.e. carbazole, fluoranthene, pyrene and benzo(a)pyrene). Significant discrepancies occurred far more frequently for benzo(a)pyrene in extracts of the solid fractions than for any other compound or extract type. As a result of interferences caused by closely eluting or overlapping peaks and a sloping baseline, it appears that GC-FID considerably over estimated the concentration of this compound in the solid fraction.

It is generally accepted that GC-MS should give more reliable results than GC-FID. However, when the levels of background interferences are high (i.e. steeply sloping baseline) sample extracts must be considerably diluted in order to avoid saturation of the MS. Therefore, detection limits can be raised significantly and a compound detectable by GC-FID may not be detectable by GC-MS. Thus, whilst the GC/GC-MS comparisons were helpful in providing some additional analytical security, there were some difficulties in interpreting the true significance of some of the data in Table B-21.

In recent years, considerable improvements have been made in extraction and clean-up techniques and chromatographic column technology. However, difficulties still remain in performing trace organic analyses for extracts of complex matrices typical of wastewaters and sludges. During the course of this study, extracts of influent solid samples caused rapid deterioration in the condition of the GC injector and fused silica column. Therefore, frequent cleaning or replacement of these components was required.

Also, difficulties in integration were caused by heavily spiked and steeply sloping baselines. In these cases, computerized peak area integration has to be replaced by more accurate and much slower manual peak height measurements.

APPENDIX B - ABBREVIATIONS

1,4-DB = 1,4-Dichlorobenzene
N = Naphthalene
A = Acenaphthylene
2,6-DT = 2,6-Dinitrotoluene
DBF = Dibenzofuran
F = Fluorene
C = Carbazole
Flu = Fluoranthene
P = Pyrene
B(a)P = Benzo(a)pyrene
I = Influent
E = Effluent
WAS = Waste activated sludge
L = Liquid
S = Solid
US = Unspiked
SP = Spiked
ND = Not Detected
NC = Not Calculated
T = Trace
RSD = Relative Standard Deviation
NR = No Result
DWB = Dry Weight Basis

TABLE B-1. PHASE 1 - DAY 1 RESULTS OF GC ANALYSIS FOR PAH GROUP IN SAMPLE SOLID FRACTIONS

SAMPLE	SP/US	CONCENTRATION (ug/g) AND RSD (%)									
		1,4-DB	N	A	2,6-DT	DBF	F	C	Flu	P	B(a)P
I 11S	US	ND	3	5	ND	4	8	19	37	25	41
I 12S	US	ND	1	5	ND	3	7	24	36	27	45
I 13S	US	ND	3	5	ND	4	7	19	37	24	38
Mean		ND	2	5	ND	4	7	21	37	25	41
RSD (%)		0	50	0	0	16	8	14	2	6	8
I 14S	SP (100)	ND	17	60	ND	70	79	102	139	123	150
I 15S	SP (100)	ND	22	59	ND	67	76	99	127	115	150
Mean		ND	20	60	ND	69	78	101	133	119	150
I 16S	SP (50)	ND	3	21	ND	26	33	76	111	104	105
I 17S	SP (50)	ND	3	20	ND	29	37	59	86	76	114
Mean		ND	3	21	ND	28	35	68	99	90	110
I 18S Blank	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
WAS 11S	US	ND	ND	ND	ND	ND	ND	12	8	7	32
WAS 12S	US	ND	ND	ND	ND	ND	ND	12	8	8	26
WAS 13S	US	ND	ND	ND	ND	ND	ND	8	8	7	23
Mean		ND	ND	ND	ND	ND	ND	11	8	7	27
RSD (%)		0	0	0	0	0	0	22	0	8	17
WAS 14S	SP (100)	ND	2	14	ND	23	30	86	93	94	129
WAS 15S	SP (100)	ND	3	21	ND	30	37	84	110	97	131
Mean		ND	3	18	ND	27	34	85	102	96	130
WAS 16S	SP (50)	ND	ND	5	ND	9	12	41	60	50	70
WAS 17S	SP (50)	ND	ND	8	ND	12	16	52	72	58	76
Mean		ND	ND	7	ND	11	14	47	66	54	73
WAS 18S Blank	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	5
I-S	SP (100)	0	18	55	0	65	71	80	96	94	109
I-S	SP (50)	0	2	32	0	48	56	94	124	130	138
WAS-S	SP (100)	0	3	18	0	27	34	74	94	88	103
WAS-S	SP (50)	0	0	14	0	22	28	72	116	94	92

Notes: Sampling date - August 18, 1982

TABLE B-2. PHASE 1 - DAY 1 RESULTS OF GC ANALYSIS FOR PAH GROUP IN SAMPLE LIQUID FRACTIONS

SAMPLE	SP/US	CONCENTRATION (ug/L) AND RSD (%)									
		1,4-DB	N	A	2,6-DT	DBF	F	C	Flu	P	B(a)P
I 11L	US	ND	ND	3	ND	2	3	10	4	3	3
I 12L	US	ND	4	5	ND	2	3	11	2	1	ND
I 13L	US	ND	ND	3	ND	1	3	12	3	2	1
I 14L	US	ND	1	5	ND	2	3	11	2	1	ND
Mean		ND	1	4	ND	2	3	11	3	2	1
RSD (%)		0	151	29	0	29	0	7	35	55	141
I 15L	SP(100)	ND	67	86	19	86	89	103	88	88	84
I 16L	SP(100)	ND	16	71	22	85	94	106	99	100	94
Mean		ND	42	79	21	86	92	105	94	94	89
I 17L (a)(b)	SP(50)	ND	14	17	ND	13	14	24	14	14	18
I 18L Blank	US	ND	1	ND	ND	ND	ND	ND	ND	ND	2
E 11L	US	ND	1	T	ND	ND	ND	1	1	T	ND
E 12L	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E 13L	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E 14L	US	ND	1	ND	ND	ND	ND	ND	ND	ND	ND
Mean		ND	T	ND	ND	ND	ND	ND	ND	ND	ND
RSD (%)		0	NC	NC	0	0	0	NC	NC	NC	0
E 15L	SP(100)	ND	10	48	ND	70	85	101	101	101	99
E 16L	SP(100)	ND	3	42	ND	64	76	93	85	87	88
Mean		ND	7	45	ND	67	81	97	93	94	94
E 17L (b)	SP(50)	ND	39	44	14	45	47	54	51	51	48
E 18L Blank	US	ND	ND	ND	ND	ND	ND	1	ND	ND	1
WAS 11L	US	ND	ND	ND	ND	ND	ND	ND	1	1	1
WAS 12L	US	ND	ND	ND	ND	ND	ND	ND	1	1	1
Mean		ND	ND	ND	ND	ND	ND	ND	1	1	1
Blank	SP(100)	ND	51	73	ND	80	85	76	92	92	89
		RECOVERY (%)									
I-L	SP(100)	0	41	75	21	84	89	94	91	92	88
I-L	SP(50)	0	26	26	0	22	22	26	22	24	34
E-L	SP(100)	0	7	45	0	67	81	97	93	94	94
E-L	SP(50)	0	78	88	28	90	94	108	102	102	96

Notes: Sampling date - August 18, 1982

a) Poor results for this sample suggest sample loss or poor performance during extraction and clean-up.

b) Analyst omitted to spike one influent and effluent sample at 50 mg/L concentration. Therefore, there are 4 unspiked replicates in each set of liquids for Day 1 and only 1 replicate spiked at 50 mg/L.

TABLE B-3. PHASE 1 - DAY 2 RESULTS OF GC ANALYSIS FOR PAH GROUP IN SAMPLE SOLID FRACTIONS

SAMPLE	SP/US	CONCENTRATION (ug/g) AND RSD (%)									
		1,4-DB	N	A	2,6-DT	DBF	F	C	Flu	P	B(a)P
I 21S	US	ND	ND	4	ND	4	9	21	42	23	23
I 22S	US	ND	ND	6	ND	6	9	28	48	30	44
I 23S	US	ND	ND	4	ND	4	8	28	43	26	36
Mean		ND	ND	5	ND	5	9	26	44	27	34
RSD (%)		0	0	25	0	25	7	16	7	10	31
I 24S	SP (100)	ND	10	57	T	68	82	106	122	105	118
I 25S	SP (100)	ND	8	50	16	60	72	102	125	110	164
Mean		ND	9	54	8	64	77	104	124	108	141
I 26S	SP (50)	ND	5	21	ND	23	29	49	67	51	70
I 27S	SP (50)	ND	8	34	ND	38	49	71	95	75	120
Mean		ND	7	28	ND	31	39	60	81	63	95
I 28S Blank	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	4
WAS 21S	US	ND	ND	ND	ND	ND	ND	15	15	10	22
WAS 22S	US	ND	ND	ND	ND	ND	2	14	13	9	17
WAS 23S	US	ND	ND	ND	ND	ND	ND	11	15	9	13
Mean		ND	ND	ND	ND	ND	1	13	14	9	17
RSD (%)		0	0	0	0	0	172	16	8	6	26
WAS 24S	SP (100)	ND	18	54	13	62	70	125	106	95	125
WAS 25S	SP (100)	ND	14	51	11	59	68	104	102	94	142
Mean		ND	16	53	12	61	69	115	104	95	134
WAS 26S	SP (50)	ND	6	25	10	30	35	95	66	55	84
WAS 27S	SP (50)	ND	6	25	ND	30	35	56	82	66	69
Mean		ND	6	25	5	30	35	76	74	61	77
WAS 28S Blank	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	T
RECOVERY (%)											
I-S	SP (100)	0	9	49	8	59	68	78	80	81	107
I-S	SP (50)	0	14	46	0	52	60	68	74	72	122
WAS-S	SP (100)	0	16	53	12	61	68	102	90	86	117
WAS-S	SP (50)	0	12	50	10	60	68	126	120	104	120

Notes: Sampling date - September 15, 1982.

TABLE B-4. PHASE 1 - DAY 2 RESULTS OF GC ANALYSIS FOR PAH GROUP IN SAMPLE LIQUID FRACTIONS

SAMPLE	SP/US	CONCENTRATION (ug/L) AND RSD (%)									
		1,4-DB	N	A	2,6-DT	DBF	F	C	Flu	P	B(a)P
I 21L	US	ND	3	5	ND	3	3	10	3	2	3
I 22L	US	ND	ND	4	ND	3	4	14	3	2	2
I 23L	US	ND	4	6	ND	3	4	6	3	2	3
MEAN		ND	2	5	ND	3	4	10	3	2	3
RSD (%)		0	89	20	0	0	16	40	0	0	22
I 24L	SP (100)	ND	39	79	8	83	88	83	89	88	79
I 25L	SP (100)	ND	24	67	ND	71	76	75	76	75	72
MEAN		ND	32	73	4	77	82	79	83	82	76
I 26L	SP (50)	ND	23	39	ND	39	41	38	41	40	36
I 27L	SP (50)	ND	34	48	ND	47	47	53	48	46	41
MEAN		ND	29	44	ND	43	44	46	45	43	39
I 28L Blank	US	ND	ND	ND	ND	ND	ND	1	T	ND	1
E 21L	US	ND	1	T	ND	ND	T	2	T	T	1
E 22L	US	ND	1	1	ND	ND	T	1	1	1	1
E 23L	US	ND	T	1	ND	ND	T	1	1	T	1
MEAN		ND	1	1	ND	ND	T	1	1	T	1
RSD (%)		0	NC	NC	0	0	0	35	NC	NC	0
E 24L	SP (100)	ND	3	34	ND	58	76	82	91	90	77
E 25L	SP (100)	ND	3	34	ND	58	75	88	90	89	78
MEAN		ND	3	34	ND	58	76	85	91	90	78
E 26L	SP (50)	ND	26	37	ND	41	44	43	47	46	35
E 27L	SP (50)	N O S A M P L E									
MEAN		--	--	--	--	--	--	--	--	--	--
E 28L Blank	US	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
WAS 21L	US	ND	ND	ND	ND	ND	ND	2	1	1	9
WAS 22L	US	ND	ND	ND	ND	ND	ND	T	1	1	5
MEAN		ND	ND	ND	ND	ND	ND	1	1	1	8
BLANK	SP (100)	ND	50	66	ND	73	79	73	86	86	71
BLANK	SP (50)	ND	21	34	ND	39	42	43	47	46	38
RECOVERY (%)											
I-L	SP (100)	0	30	68	4	74	78	69	80	80	73
I-L	SP (50)	0	54	78	0	80	80	72	84	82	72
E-L	SP (100)	0	2	33	0	58	76	84	90	90	77
E-L	SP (50)	0	50	72	0	82	88	84	92	92	68

Notes: Sampling date - September 15, 1982

TABLE B-5. SUMMARY OF COMPOUND RECOVERIES OBTAINED DURING PHASE 1 FOR PAH GROUP

SAMPLE TYPE	SAMPLING DAY	RECOVERY (%)									
		1,4-DB	N	A	2,6-DB	DBF	F	C	FLU	P	B(a)P
I-S (100)	1	0	18	55	0	65	71	80	96	94	109
I-S (50)	1	0	2	32	0	48	56	94	124	130	138
I-S (100)	2	0	9	49	8	59	68	78	80	81	107
I-S (50)	2	0	14	46	0	52	60	68	74	72	122
Mean		0	11	46	3	56	64	80	94	94	119
WAS-S(100)	1	0	3	18	0	27	34	74	94	88	103
WAS-S(50)	1	0	0	14	0	22	28	72	116	94	92
WAS-S(100)	2	0	16	53	12	61	68	102	90	86	117
WAS-S(50)	2	0	12	50	10	60	68	126	120	104	120
Mean		0	8	34	6	43	50	94	105	93	108
Grand Mean		0	9	40	5	49	49	87	99	94	102
Std. Dev.		0	7	16	5	16	23	23	19	18	37
I-L (100)	1	0	41	75	21	84	89	94	91	92	88
I-L (50)	1	0	26	26	0	22	22	26	22	24	34
I-L (100)	2	0	30	68	4	74	78	69	80	80	73
I-L (50)	2	0	54	78	0	80	80	72	84	82	72
Mean		0	38	62	6	65	67	65	69	70	67
E-L (100)	1	0	7	45	0	67	81	97	93	94	94
E-L (50)	1	0	78	88	28	90	94	108	102	102	96
E-L (100)	2	0	2	33	0	58	76	84	90	90	77
E-L (50)	2	0	50	72	0	82	88	84	92	92	68
Mean		0	34	60	7	74	85	93	94	95	84
Grand Mean		0	36	61	8	70	76	79	82	82	75
Std. Dev.		0	25	23	11	22	23	25	25	24	20

Notes: Spiking concentrations are given in parenthesis and the units are ug/g for solid fractions and ug/L for liquid fractions.

TABLE B-6. COMPARISON OF RESULTS OBTAINED BY GC-FID AND GC-MS DURING PHASE 1 OF THE STUDY FOR PAH GROUP

COMPOUND NAME	SAMPLING DAY	CONCENTRATION							
		INFLUENT				EFFLUENT LIQUID (ug/L)		WAS SOLID (ug/g)	
		LIQUID (ug/L)		SOLID (ug/g)					
		GC	GC-MS	GC	GC-MS	GC	GC-MS	GC	GC-MS
Acenaphthylene	1	3	2	5	7	ND	ND	ND	Trace
	2	4	<10	4	4	1	ND	ND	ND
Benzo(a)phrene	1	1	ND	38	23	ND	ND	26	16
	2	2	<10	36	5	1	ND	17	4
Fluorene	1	3	1	7	5	ND	Trace	ND	Trace
	2	4	<10	8	7	Trace	ND	2	ND
Fluoranthene	1	3	1	37	35	ND	Trace	8	7
	2	3	<10	43	47	1	ND	13	11
Naphthalene	1	ND	Trace	3	3	ND	Trace	ND	ND
	2	ND	ND	ND	1	1	<10	ND	1
Pyrene	1	2	Trace	24	19	ND	Trace	8	5
	2	2	<10	26	35	1	ND	9	13
Carbazole	1	12	NR	19	NR	ND	NR	12	NR
	2	14	NR	28	NR	1	NR	14	NR
Dibenzofuran	1	1	NR	4	NR	ND	NR	ND	NR
	2	3	NR	4	NR	ND	NR	ND	NR

Notes: GC analyses were performed by CANVIRO CONSULTANTS LTD.

GC-MS analyses were performed on a Finnigan 1020 GC-MS at the Wastewater Technology Centre in Burlington, Ontario.

Solid concentrations are expressed on a dry weight basis.

NR = No result; compound not measured.

ND = Not detected.

Trace = Compound was detectable, but the concentration was too low to measure.

TABLE B-7. PHASE 2 RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1982	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Dec 6-7 Mon - Tues	I 3L	ug/L		ND	3	1	2	4	1	1	8
	E 3L			ND	ND	ND	ND	ND	T	T	T
	Blank 3L			ND	ND	ND	ND	ND	ND	ND	ND
	I 3S	ug/g	93.0	7	8	8	12	17	23	16	89
	WAS 3S	(DWB)	90.4	T	T	T	T	9	24	16	22
	Blank 3S			ND	ND	ND	ND	ND	ND	ND	ND
Dec 20-21 Mon - Tues	I 4L	ug/L		ND	20	54	63	53	85	65	ND
	E 4L			T	ND	1	2	ND	T	T	ND
	Blank 4L			ND	ND	ND	ND	ND	ND	ND	ND
	I 4S	ug/g	93.8	385	69	258	394	106	1533	1040	475
	WAS 4S	(DWB)	90.9	T	T	T	T	12	41	50	13
	Blank 4S			ND	ND	ND	ND	ND	ND	ND	ND
1983 Jan 5-6 Wed - Thurs	I 5L	ug/L		ND	6	2	3	7	3	2	14
	E 5L			ND	ND	ND	ND	ND	T	T	ND
	R 5L			ND	5	5	7	9	6	4	9
	Blank 5L			ND	ND	ND	ND	ND	ND	ND	ND
	I 5S	ug/g	89.9	6	13	13	14	20	77	45	205
	WAS 5S	(DWB)	87.9	T	T	T	T	25	62	59	57
	R 5S		89.5	13	11	26	35	70	187	144	31
	Blank 5S										

	RECOVERY (%)									
SAMPLE	SPIKE VOL. (ml)	NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Blank 3L	2	71	102	107	110	139	158	155	139
Blank 3S	2	63	71	74	74	73	79	79	74
Blank 4L	2	72	97	102	102	112	116	113	112
Blank 4S	2	78	89	93	95	110	109	108	105
Blank 5L	2	74	105	106	104	103	117	115	110
Blank 5S	2	64	104	112	113	129	131	128	129

TABLE B-8. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Jan 11-12 Tues - Wed	I 6L	ug/L		ND	1	2	2	3	3	3	33
	E 6L			ND	ND	ND	ND	ND	ND	ND	ND
	R 6L			ND	ND	2	4	6	10	8	61
	Blank 6L			ND	ND	ND	ND	ND	ND	ND	ND
	I 6S	ug/g	90.5	5	11	11	16	17	77	47	157
	WAS 6S	(DWB)	80.9	ND	ND	5	ND	ND	41	29	95
	R 6S		87.8	2	5	10	13	30	167	166	165
	Blank 6S			ND	ND	ND	ND	ND	ND	ND	ND
Jan 18-19 Tues - Wed	I 7L	ug/L		ND	3	2	2	9	3	2	18
	E 7L			ND	ND	ND	ND	ND	ND	ND	ND
	R 7L			T	1	5	9	10	19	14	91
	Blank 7L			ND	ND	ND	ND	ND	ND	ND	ND
	I 7S	ug/g	90.4	4	8	7	14	25	76	55	100
	WAS 7S	(DWB)	84.4	T	T	T	T	18	25	23	14
	R 7S		90.0	4	13	17	26	12	127	109	203
	Blank 7S			ND	ND	ND	ND	ND	ND	ND	ND
Jan 25-26 Tues - Wed	I 8L	ug/L		ND	3	2	4	4	1	1	4
	E 8L			ND	ND	ND	ND	ND	ND	ND	ND
	R 8L			ND	T	5	7	3	9	6	32
	Blank 8L			ND	ND	ND	ND	ND	ND	ND	ND
	I 8S	ug/g	91.7	3	8	14	16	38	37	30	62
	WAS 8S	(DWB)	88.7	ND	ND	T	T	15	18	18	ND
	R 8S		89.6	2	2	6	10	22	74	59	41
	Blank 8S			ND	ND	ND	ND	ND	ND	ND	ND

	RECOVERY (%)									
	SAMPLE	SPIKE VOL. (mL)	NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	Blank 6L	2	70	105	110	110	103	124	121	118
	Blank 6S	2	88	102	108	105	120	114	114	114
	Blank 7L	2	55	89	94	95	84	107	103	85
	Blank 7S	2	76	90	97	96	96	107	103	86
	Blank 8L	2	67	96	100	102	92	101	95	76
	Blank 8S	2	58	92	98	102	97	101	100	88

TABLE B-9. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Apr 13-14 Wed - Thurs	I 91L	ug/L		3	3	1	1	4	1	1	7
	I 92L			2	3	1	1	5	1	1	8
	Mean			3	3	1	1	5	1	1	8
	E 91L			ND	ND	ND	ND	ND	ND	ND	ND
	R 91L			ND	1	1	1	2	2	3	34
	R 92L			ND	1	1	1	4	3	4	55
	Mean			ND	1	1	1	3	3	4	45
	Blank 9L			ND	ND	ND	ND	ND	ND	ND	ND
	I 91S	ug/g (DWB)		3	3	3	3	27	23	18	87
	I 92S			4	4	6	10	28	25	19	82
	Mean		95.7	4	4	5	7	28	24	19	85
	WAS 91S		84.7	ND	2	3	2	41	22	25	53
	R 91S		91.6	2	1	4	2	31	21	21	55
	Blank 9S			ND	ND	ND	ND	ND	ND	ND	ND
				RECOVERY (%)							
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 93L	2		75	88	94	98	101	100	102	101
	I 94L	1		86	98	104	102	108	106	104	120
	R 93L	2		18	83	94	101	106	116	105	154(a)
	I 93S	2		76	86	91	90	103	83	59	53(b)
	I 94S	1		70	78	80	68	70	92	60	8(c)
	R 92S	2		57	75	78	75	90	105	58	76
	Blank 9S	2		79	94	97	100	107	106	107	106

Notes:
(a) Sample was evaporated to dryness, hence poor recovery of naphthalene.
(b) Interference problem affected measurement of fluoranthene and pyrene.
(c) Poor chromatography for benzo(a)pyrene, i.e.
- steeply sloping baseline
- closely eluting adjacent peaks
- in spiked samples peak shape for B(a)P was poor

TABLE B-10. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Apr 21-22 Thurs - Fri	I 101L	ug/L		4	1	1	1	9	1	1	4
	I 102L			4	1	T	1	12	1	1	5
	Mean			4	1	1	1	11	1	1	5
	E 101L			ND	ND	ND	ND	ND	ND	ND	ND
	Blank 10L			ND	ND	ND	ND	ND	ND	ND	ND
	I 101S	ug/g (DWB)		3	T	2	7	39	22	17	75
	I 102S			3	T	5	3	41	24	18	87
	Mean		94.1	3	T	4	5	40	23	18	81
	WAS 101S			ND	ND	NR	ND	24	17	16	29
	WAS 102S			ND	ND	NR	ND	23	14	14	22
	Mean		88.5	ND	ND	NR	ND	24	16	15	26
	Blank 10S			ND	ND	ND	ND	ND	ND	ND	ND
				RECOVERY (%)							
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 103L	2		103	113	118	120	129	122	123	128
	I 103S	2		81	97	93	107	113	94	64	82
	Blank 10S	2		76	90	95	97	115	102	102	101

TABLE B-11. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE - 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Apr 26-27 Tues - Wed	I 111L	ug/L		9	T	1	1	16	1	1	8
	I 112L			9	T	1	1	18	1	1	8
	Mean			9	T	1	1	17	1	1	8
	E 111L			T	T	T	T	T	ND	ND	ND
	R 111L			T	ND	1	1	1	1	1	14
	Blank 11L			ND	ND	ND	ND	ND	ND	ND	ND
	I 111S	ug/g (DWB)		2	T	NR	2	41	18	13	62
	I 112S			2	T	NR	2	39	17	12	67
	Mean		92.8	2	T	NR	2	40	18	13	65
	WAS 111S		88.9	ND	ND	NR	ND	32	13	13	21
	R 111S			1	ND	4	T	28	14	13	47
	R 112S			1	ND	NR	T	30	15	15	57
	Mean		90.7	1	ND	4	T	29	15	14	52
	Blank 11S			ND	ND	ND	ND	ND	ND	ND	ND
	RECOVERY (%)										
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 113L	2		96	108	112	112	95	112	109	135
	R 112L	2		97	108	111	112	123	113	115	114
	I 113S	2		73	88	88	93	98	80	68	63
	R 113S	2		75	88	94	92	109	112	65	91
	Blank 11S	2		77	97	104	109	129	125	123	118

TABLE B-12. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE · 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
May 2-3 Mon - Tues	I 121L	ug/L		1	T	1	1	12	T	T	3
	I 122L			T	T	1	1	8	T	1	2
	Mean			1	T	1	1	10	T	1	3
	E 121L			T	ND	ND	ND	T	ND	ND	ND
	Blank 12L			ND	ND	ND	ND	ND	ND	ND	ND
	I 121S	ug/g (DWB)		2	ND	T	2	36	17	13	40
	I 122S			2	T	T	2	33	17	14	44
	Mean		92.5	2	ND	T	2	35	17	14	42
	WAS 121S			ND	ND	NR	ND	28	9	10	15
	WAS 122S			ND	ND	NR	ND	21	10	9	12
	Mean		91.7	ND	ND	NR	ND	25	10	10	14
	Blank 12S			ND	ND	ND	ND	ND	ND	ND	ND
	RECOVERY (%)										
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 123L	2		93	109	113	116	130	123	122	121
	I 124L	1		88	96	98	96	106	106	102	102
	I 123S	2		78	93	98	99	114	88	76	99
	I 124S	1		62	80	82	80	70	82	60	58
	Blank 12S	2		77	97	104	109	129	125	123	118

TABLE B-13. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
June 22-23 Wed - Thurs	I 131L	ug/L		T	T	ND	1	9	1	1	4
	I 132L			1	T	1	1	11	1	1	6
	Mean			T	T	1	1	10	1	1	5
	E 131L			T	ND	ND	ND	ND	ND	ND	ND
	Blank 13L			ND	ND	ND	ND	ND	ND	ND	ND
	I 131S	ug/g (DWB)		T	ND	T	7	42	25	13	59
	I 132S			T	ND	3	7	40	28	13	61
	Mean		92.3	T	ND	2	7	41	27	13	60
	WAS 131S			ND	T	ND	T	20	6	5	19
	WAS 132S			T	T	ND	ND	18	6	5	17
	Mean		90.0	T	T	ND	T	19	6	5	18
	Blank 13S			ND	ND	ND	ND	ND	ND	ND	ND
				RECOVERY (%)							
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 133L	2		68	81	88	88	97	97	96	100
	I 133S	2		60	77	74	78	72	84	68	74
	Blank 13S	2		54	75	82	83	97	97	97	97

TABLE B-14. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE - 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
July 11-12 Mon - Tues	I 141L	ug/L		3	T	2	1	19	1	1	5
	I 142L			3	T	2	1	20	1	1	5
	Mean			3	T	2	1	20	1	1	5
	E 141L			T	ND	ND	ND	ND	ND	ND	ND
	R 141L			T	ND	1	1	2	1	1	8
	R 142L			T	ND	ND	1	2	1	1	12
	Mean			T	ND	1	1	2	1	1	12
	Blank 14L			ND	ND	ND	ND	ND	ND	ND	ND
	I 141S	ug/g (DWB)		3	ND	4	8	33	22	14	55
	I 142S			3	ND	3	6	31	20	13	57
	Mean		91.6	3	ND	4	7	32	21	14	56
	WAS 141S		85.8	ND	ND	ND	ND	15	4	4	11
	R 141S		87.9	ND	ND	1	1	18	11	8	34
	Blank 14S			ND	ND	ND	ND	ND	ND	ND	ND
				RECOVERY (%)							
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 143L	2		73	83	95	90	103	100	99	102
	I 144L	1		82	88	98	95	106	106	104	100
	R 143L	2		57	73	100	86	97	94	92	96
	I 143S	2		60	80	78	81	80	83	54	83
	I 144S	1		40	76	76	84	84	96	66	106
	R 142S	2		60	83	86	91	95	120	71	78
	Blank 14S	2		61	70	77	80	96	96	96	100

TABLE B-15. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Aug 2-3 Tues - Wed	I 151L	ug/L		12	3	2	1	20	1	1	11
	I 152L			12	1	2	1	20	1	1	10
	Mean			12	2	2	1	20	1	1	11
	E 151L			T	ND	ND	ND	ND	ND	ND	ND
	R 151L			ND	ND	T	1	2	1	1	3
	Blank 15L			ND	ND	ND	ND	ND	ND	ND	ND
	I 151S	ug/g (DWB)		2	6	5	4	31	23	14	75
	I 152S			4	6	5	4	31	23	15	78
	Mean		89.9	3	6	5	4	31	23	15	77
	WAS 151S		88.2	2	ND	ND	ND	23	14	10	4
	R 151S			2	ND	ND	ND	30	25	20	41
	R 152S			2	ND	ND	T	22	25	20	39
	Mean		88.8	2	ND	ND	T	26	25	20	40
	Blank 15S			ND	ND	ND	ND	ND	ND	ND	ND
				RECOVERY (%)							
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 153L	2		75	85	116	92	107	102	102	105
	R 152L	2		78	84	89	90	83	103	101	107
	I 153S	2		61	73	80	79	65	68	70	69
	R 153S	2		44	75	79	87	71	93	71	79
	Blank 15S	2		60	71	79	83	85	98	99	101

TABLE B-16. RESULTS OF GC ANALYSES OF PAH GROUP

SAMPLING DATE 1983	SAMPLE	UNITS	TOTAL SOLIDS (%)	CONCENTRATION							
				NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Aug 8-9 Mon - Tues	I 161L	ug/L		12	1	1	1	17	2	1	17
	I 162L			10	1	1	1	16	2	1	15
	Mean			11	1	1	1	17	2	1	16
	E 161L			ND	ND	ND	ND	ND	ND	ND	ND
	Blank 16L			ND	ND	ND	ND	ND	ND	ND	ND
	I 161S	ug/g (DWB)		2	T	3	4	30	21	15	98
	I 162S			2	T	3	4	39	21	14	100
	Mean			2	T	3	4	35	21	15	99
	WAS 161S			1	T	ND	ND	29	10	7	14
	WAS 162S			1	T	ND	ND	37	10	8	14
	Mean			1	T	ND	ND	33	10	8	14
	Blank 16S			ND	ND	ND	ND	ND	ND	ND	ND
	RECOVERY (%)										
	SAMPLE	SPIKE VOL. (mL)		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
	I 163L	2		83	89	94	94	79	98	98	98
	I 164L	1		84	88	94	94	86	96	96	72
	I 163S	2		80	91	90	103	68	95	81	78
	I 164S	1		68	86	84	92	64	82	72	78
	Blank 16S	2		65	73	79	81	90	90	90	91

TABLE B-17. SUMMARY OF ANALYTICAL PRECISION OBTAINED IN PHASE 2 FOR PAH GROUP IN SAMPLE SOLID FRACTION

SAMPLING DATE 1983	SAMPLE	CONCENTRATION (ug/g DWB) ± RSD(%)							
		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Apr 13-14	I 9S	4 ± 20	4 ± 20	5 ± 47	7 ± 76	28 ± 3	24 ± 6	19 ± 4	85 ± 4
21-22	I 10S	3 ± 0	T ± 0	4 ± 61	5 ± 57	40 ± 4	23 ± 6	18 ± 4	81 ± 10
26-27	I 11S	2 ± 0	T ± 0	NR	2 ± 0	40 ± 4	18 ± 4	13 ± 6	65 ± 5
May 2-3	I 12S	2 ± 0	ND ± 50	T ± 0	2 ± 0	35 ± 6	17 ± 0	14 ± 5	42 ± 7
June 22-23	I 13S	T ± 0	ND ± 0	2 ± 71	7 ± 0	41 ± 3	27 ± 8	13 ± 0	60 ± 2
July 11-12	I 14S	3 ± 0	ND ± 0	4 ± 20	7 ± 20	32 ± 4	21 ± 7	14 ± 5	56 ± 3
26-27	I 15S	3 ± 47	6 ± 0	5 ± 0	4 ± 0	31 ± 0	23 ± 0	15 ± 5	77 ± 3
Aug 8-9	I 16S	2 ± 0	T ± 0	3 ± 0	4 ± 0	35 ± 18	21 ± 0	15 ± 5	99 ± 1
Apr 21-22	WAS 10S	ND ± 0	ND ± 0	NR	ND ± 0	24 ± 3	16 ± 14	15 ± 9	26 ± 19
May 2-3	WAS 12S	ND ± 0	ND ± 0	NR	ND ± 0	25 ± 20	10 ± 7	10 ± 7	14 ± 16
June 22-23	WAS 13S	T ± 50	T ± 0	ND ± 0	T ± 0	19 ± 7	6 ± 0	5 ± 0	18 ± 8
Aug 8-9	WAS 16S	1 ± 0	T ± 0	ND ± 0	ND ± 0	33 ± 17	10 ± 0	8 ± 9	14 ± 0
Apr 26-27	R 11S	1 ± 0	ND ± 0	NR	T ± 0	29 ± 5	15 ± 5	14 ± 10	52 ± 14
July 26-27	R 15S	2 ± 0	ND ± 0	ND ± 0	T ± 50	26 ± 22	25 ± 0	20 ± 0	40 ± 4

TABLE B-18. SUMMARY OF ANALYTICAL PRECISION OBTAINED IN PHASE 2 FOR PAH GROUP IN SAMPLE LIQUID FRACTION

SAMPLING DATE 1983	SAMPLE	CONCENTRATION (ug/L) ± RSD(%)							
		NAPHTHALENE	ACENAPHTHYLENE	DBF	FLUORENE	CARBAZOLE	FLUORANTHENE	PYRENE	B(a)P
Apr 13-14	I 9L	3 ± 28	3 ± 0	1 ± 0	1 ± 0	5 ± 16	1 ± 0	1 ± 0	8 ± 9
21-22	I 10L	4 ± 0	1 ± 0	1 ± 0	1 ± 0	11 ± 20	1 ± 0	1 ± 0	5 ± 16
26-27	I 11L	9 ± 0	T ± 0	1 ± 0	1 ± 0	17 ± 8	1 ± 0	1 ± 0	8 ± 0
May 2-3	I 12L	1 ± 0	T ± 0	1 ± 0	1 ± 0	10 ± 28	T ± 0	1 ± 0	3 ± 28
June 22-23	I 13L	T ± 0	T ± 0	1 ± 50	1 ± 0	10 ± 14	1 ± 0	1 ± 0	5 ± 28
July 11-12	I 14L	3 ± 0	T ± 0	2 ± 0	1 ± 0	20 ± 4	1 ± 0	1 ± 0	5 ± 0
26-27	I 15L	12 ± 0	2 ± 71	2 ± 0	1 ± 0	20 ± 0	1 ± 0	1 ± 0	11 ± 7
Aug 8-9	I 16L	11 ± 13	1 ± 0	1 ± 0	1 ± 0	17 ± 4	2 ± 0	1 ± 0	16 ± 9
Apr 13-14	R 9L	ND ± 0	1 ± 0	1 ± 0	1 ± 0	3 ± 47	3 ± 28	4 ± 20	45 ± 33
July 11-12	R 14L	T ± 0	ND ± 0	1 ± 50	1 ± 0	2 ± 0	1 ± 0	1 ± 0	10 ± 28

TABLE B-19. SUMMARY OF COMPOUND RECOVERIES OBTAINED DURING PHASE 2 FOR PAH GROUP FROM SOLID FRACTIONS

SAMPLE TYPE	SAMPLING DAY	RECOVERY (%)							
		N	A	DBF	F	C	FLU	P	B(a)P
I-S (100)	9	76	86	91	90	103	83	59	53
I-S (50)	9	70	78	80	68	70	92	60	8
I-S (100)	10	81	97	93	107	113	94	64	82
I-S (100)	11	73	88	88	93	98	80	68	63
I-S (100)	12	78	93	98	99	114	88	76	99
I-S (50)	12	62	80	82	80	70	82	60	58
I-S (100)	13	60	77	74	78	72	84	68	74
I-S (100)	14	60	80	78	81	80	83	54	83
I-S (50)	14	40	76	76	84	84	96	66	106
I-S (100)	15	61	73	80	79	65	68	70	69
I-S (100)	16	80	91	90	103	68	95	81	78
I-S (50)	16	68	86	84	92	64	82	72	78
Mean		67	84	85	88	83	86	67	71
Std. Dev.		12	8	7	12	19	8	8	25
R-S (100)	9	57	75	78	75	90	105	58	76
R-S (100)	11	75	88	94	92	109	112	65	91
R-S (100)	14	60	83	86	91	95	120	71	78
R-S (100)	15	44	75	79	87	71	93	71	79
Mean		59	80	84	86	91	108	66	81
Std. Dev.		13	6	7	8	16	11	6	7
Grand Mean		65	83	84	87	85	91	66	74
Std. Dev.		12	7	7	10	18	13	7	22

TABLE B-20. SUMMARY OF COMPOUND RECOVERIES OBTAINED DURING PHASE 2 FOR PAH GROUP FROM LIQUID FRACTIONS

SAMPLE TYPE	SAMPLING DAY	RECOVERY (%)							
		N	A	DBF	F	C	FLU	P	B(a)P
I-L (100)	9	75	88	94	98	101	100	102	101
I-L (50)	9	86	98	104	102	108	106	104	120
I-L (100)	10	103	113	118	120	129	122	123	128
I-L (100)	11	96	108	112	112	95	112	109	135
I-L (100)	12	93	109	113	116	130	123	122	121
I-L (50)	12	88	96	98	96	106	106	102	102
I-L (100)	13	68	81	88	88	97	97	96	100
I-L (100)	14	73	83	95	90	103	100	99	102
I-L (50)	14	82	88	98	95	106	106	104	100
I-L (100)	15	75	85	116	92	107	102	102	105
I-L (100)	16	83	89	94	94	79	98	98	98
I-L (50)	16	84	88	94	94	86	96	96	72
Mean		84	94	102	100	104	106	105	107
Std. Dev.		10	11	10	11	15	9	9	17
R-L (100)	9	18	83	94	101	106	116	105	154
R-L (100)	11	97	108	111	112	123	113	115	114
R-L (100)	14	57	73	100	86	97	94	92	96
R-L (100)	15	78	84	89	90	83	103	101	107
Mean		63	87	99	97	102	107	103	118
Std. Dev.		34	15	9	12	17	10	10	25
Grand Mean		79	92	101	99	104	106	104	110
Std. Dev.		20	12	10	11	15	9	9	19

TABLE B-21. COMPARISON OF RESULTS OBTAINED BY GC-FID AND GC-MS DURING PHASE 2 OF THE STUDY

COMPOUND	SAMPLING DATE 1983	SAMPLE REP.	CONCENTRATION											
			INFLUENT				EFFLUENT LIQUID (ug/L)		WAS SOLID (ug/g)		RETURN FLOW			
			LIQUID (ug/L)		SOLID (ug/g)						LIQUID (ug/L)		SOLID (ug/g)	
			GC	GC-MS	GC	GC-MS	GC	GC-MS	GC	GC-MS	GC	GC-MS	GC	GC-MS
Acenaphthylene	Jan 11-12	1	0.6	0.6	10	3	ND	NR	ND	ND	ND	ND	4	2
	Apr 26-27	1	T	<1	T	ND	T	ND	3	<1	ND	ND	ND	ND
	Aug 8-9	1	1	2	T	1	ND	ND	T	T	-	-	-	-
	Aug 8-9	2	1	ND	T	1	-	-	ND	T	-	-	-	-
Benzo(a)pyrene	Jan 11-12	1	ND	ND	142	19	ND	NR	77	14	61	ND	145	17
	Apr 26-27	1	8	ND	58	ND	ND	ND	19	31	14	ND	42	ND
	Aug 8-9	1	18	ND	84	10	ND	ND	12	4	-	-	-	-
	Aug 8-9	2	15	ND	85	8	-	-	12	5	-	-	-	-
Fluorene	Jan 11-12	1	2	2	15	6	ND	NR	ND	ND	4	4	11	7
	Apr 26-27	1	1	<1	2	ND	T	ND	2	<1	1	<1	T	ND
	Aug 8-9	1	1	2	4	5	ND	ND	ND	<1	-	-	-	-
	Aug 8-9	2	1	<1	4	5	-	-	ND	<1	-	-	-	-
Fluoranthene	Jan 11-12	1	3	2	70	46	ND	NR	33	12	10	11	146	42
	Apr 26-27	1	1	<1	17	ND	ND	ND	12	2	1	<1	12	ND
	Aug 8-9	1	2	2	18	20	ND	ND	8	12	-	-	-	-
	Aug 8-9	2	2	<1	18	26	-	-	8	14	-	-	-	-
Naphthalene	Jan 11-12	1	ND	ND	4	2	ND	NR	ND	ND	ND	ND	2	1
	Apr 26-27	1	9	10	2	ND	T	<1	ND	<1	T	<1	1	ND
	Aug 8-9	1	12	26	2	2	ND	ND	1	<1	-	-	-	-
	Aug 8-9	2	10	9	2	2	-	-	1	<1	-	-	-	-
Pyrene	Jan 11-12	1	3	3	43	37	ND	NR	23	28	8	12	146	39
	Apr 26-27	1	1	<1	12	ND	ND	ND	11	5	1	<1	12	ND
	Aug 8-9	1	1	2	13	15	ND	ND	6	11	-	-	-	-
	Aug 8-9	2	1	<1	12	21	-	-	7	13	-	-	-	-
Carbazole	Jan 11-12	1	3	ND	15	ND	ND	NR	ND	ND	6	ND	26	ND
	Apr 26-27	1	16	23	38	ND	T	ND	28	ND	1	ND	26	ND
	Aug 8-9	1	17	16	25	18	ND	ND	25	1	-	-	-	-
	Aug 8-9	2	16	6	33	25	-	-	31	ND	-	-	-	-
Dibenzofuran	Jan 11-12	1	2	ND	10	3	ND	NR	4	ND	2	4	9	3
	Apr 26-27	1	1	<1	NR	ND	T	ND	3	ND	1	<1	3	ND
	Aug 8-9	1	1	2	2	3	ND	ND	ND	<1	-	-	-	-
	Aug 8-9	2	1	<1	3	3	-	-	ND	<1	-	-	-	-

Notes: GC analyses were performed by CANVIRO Consultants Ltd.
GC-MS analyses were performed on a Finnigan 4500 GC-MS by MOE.
Solid concentrations are expressed on a day weight basis.
NR = No Result.
ND = Not Detected.
T = Trace; compound was detectable, but the concentration was too low to measure.
- = No Sample Collected.

TABLE B-22. PHASE 2 RESULTS OF PESTICIDE AND PCB ANALYSES FOR SOLID AND LIQUID FRACTIONS OF WPCP INFLUENT AND EFFLUENT

COMPOUND		DEC 6-7 1982		DEC 20-21 1982		JAN 5-6 1983		JAN 11-12 1983		JAN 18-19 1983		JAN 25-26 1983		APR 13-14 1983		APR 21-22 1983		APR 26-27 1983		MAY 2-3 1983		JUN 22-23 1983		JUL 11-12 1983		AUG 2-3 1983		AUG 8-9 1983		DETECTION LIMIT	
		S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Aldrin	I	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1		
	E	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1	1	1
A-BHC Hexachlorocyclohex	I	4	7	<1	12	<1	11	<1	13	<1	44	<1	12	14	<1	<1	4	16	5	<1	<1	NR	30	5	36	5	1	4	<1		
	E	3	5	<1	10	<1	<1	<1	2	<1	4	<1	2	<1	<1	<1	2	<1	3	<1	<1	NR	30	6	1	6	1	7	<1	1	1
B-BHC Hexachlorocyclohex	I	<1	26	<1	65	<1	43	<1	29	<1	13	<1	24	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1		
	E	<1	9	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1	1	1
G-BHC * (LINDANE)	I	<1	32	<1	26	<12	257	<1	253	<1	175	<1	36	28	40	<1	90	2	285	<1	<1	NR	<1	<1	12	3	14	<1	<1	(12)	
Hexachlorocyclohex	E	<1	38	<1	<1	<1	146	<1	91	<1	23	<1	3	<1	<1	12	<1	<1	165	<1	<1	NR	<1	<1	10	<1	2	<1	<1	1	1
A-Chlordane	I	12	<2	<1	14	<2	<2	<2	7	<2	<2	<2	2	19	<2	<2	<2	<2	6	<2	<2	NR	<2	39	<2	55	<2	45	<2		
	E	20	<2	<1	<2	<2	<2	<2	<2	<2	<2	<2	<2	11	<2	<2	<2	<2	<2	15	<2	NR	<2	55	<2	71	<2	65	<2	2	2
G-Chlordane	I	20	<2	<2	9	5	<2	6	9	<2	<2	<7	4	21	3	<2	<2	<2	6	<2	<2	NR	<2	32	<2	62	<2	55	<2	(7)	
	E	25	<2	<2	<2	<2	<2	6	<2	<2	<2	<7	<2	12	<2	<2	<2	<2	<2	10	<2	NR	<2	50	<2	75	<2	65	<2	2	2
Dieldrin	I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	5	NR	<2	<2	NR	<2	<2	<2	<2	<2	<2	<2		
	E	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	NR	<2	<2	NR	<2	<2	<2	<2	<2	37	<2	2	2
DMDT Methoxychlor	I	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	NR	<5	<5	20	<5	<5	<5	5		
	E	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	NR	<5	<5	<5	<5	<5	<5	<5	5	5
Endosulfan I	I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	NR	<2	<2	NR	<2	<2	<2	<2	<2	<2	2		
	E	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	NR	<2	<2	NR	<2	<2	<2	<2	<2	<2	<2	2	2
Endosulfan II	I	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	<4	<4	<4	<4	<4		
	E	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	<4	<4	<4	<4	<4	4	4
Endrin	I	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	<4	<4	<4	<4	<4		
	E	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	<4	<4	<4	<4	<4	4	4
Endosulfan Sulphate	I	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	12	<4	<4	<4	<4		
	E	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	NR	<4	<4	NR	<4	<4	<4	<4	<4	<4	<4	4	4
Heptachlorepoxide	I	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1		
	E	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1	1	1

Notes: NR = No Result (data not available)
Units: Liquid Fraction = ng/L
Solid Fraction = ng/g dry weight basis

* = Mass balance calculations performed for these compounds only, the majority of the data for the remaining compounds being at the analytical limit.

TABLE B-22. (cont'd) PHASE 2 RESULTS OF PESTICIDE AND PCB ANALYSES FOR SOLID AND LIQUID FRACTIONS OF WPCP INFLUENT AND EFFLUENT

COMPOUND		DEC 6-7 1982		DEC 20-21 1982		JAN 5-6 1983		JAN 11-12 1983		JAN 18-19 1983		JAN 25-26 1983		APR 21-22 1983		APR 26-27 1983		MAY 2-3 1983		JUN 22-23 1983		JUL 11-12 1983		AUG 2-3 1983		AUG 8-9 1983		DETECTION LIMIT	
		S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Heptachlor	I	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1		
	E	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1	1	1
Mirex	I	<500	<5	<5	<5	<500	<5	<500	<5	<500	<5	<500	<5	<5	<5	<5	<5	<5	<5	NR	<5	15	<5	<5	<5	5	<5		
	E	<500	<5	<5	<5	<500	<5	<500	<5	<500	<5	<500	<5	<5	<5	<5	<5	<5	<5	NR	<5	10	<5	10	<5	<5	<5	5(500)	5
Oxychlordane	I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	NR	<2	<2	<2	<2	<2	<2	<2		
	E	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	NR	<2	<2	<2	<2	<2	<2	<2	2(5)	2
OP-DDT	I	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	<5	<5	<5	<5	<5		
	E	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	<5	<5	<5	<5	<5	5	5
PCB-Total *	I	1280	70	355	105	55	85	60	<20	120	<20	130	105	<20	75	260	45	45	<20	NR	50	975	35	945	55	1405	50		
	E	2190	235	345	25	<20	20	40	<20	100	<20	60	<20	<20	<20	60	<20	650	<20	NR	<20	1650	<20	1505	<20	1385	<20	20	20
PP-DDD	I	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5	NR	<5	5	<5	10	<5	5	<5		
	E	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	10	<5	10	<5	15	<5	5	5
PP-DDE	I	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	<1	<1	1	1
	E	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NR	<1	<1	<1	<1	<1	9	<1	1	1
PP-DDT	I	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	<5	<5	<5	<5	<5		
	E	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NR	<5	<5	<5	<5	<5	<5	<5	5	5
Hexachlorobenzene	I	1	3	<1	1	<1	2	<1	3	<1	<1	1	2	<1	<1	3	2	<1	<1	NR	<1	<1	<1	2	<1	<1	<1		
	E	2	11	<1	<1	<1	2	<1	1	1	6	1	4	12	3	<1	2	6	<1	NR	<1	<1	<1	<1	<1	6	1	1	1
234 Trichlorophenol	I	NR	NR	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	NR	<100	NR	<100	<100	NR	<100	1375	<100	<100	<100	<100	<100		
	E	NR	NR	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	NR	NR	NR	NR	<100	<100	<100	<100	<100	<100	<100	100	100
2345 Tetrachlorophenol	I	NR	NR	<50	<50	660	<50	490	<50	<50	<50	<50	<50	<50	NR	<50	NR	<50	<50	NR	<50	395	<50	<50	<50	<50	<50		
	E	NR	NR	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NR	NR	NR	NR	<50	<50	<50	<50	<50	<50	<50	50	50
2356 Tetrachlorophenol	I	NR	NR	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NR	<50	NR	<50	<50	NR	<50	390	<50	<50	150	<50	<50		
	E	NR	NR	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NR	NR	NR	NR	<50	<50	<50	<50	<50	<50	<50	50	50
245 Trichlorophenol	I	NR	NR	<50	<50	90	<50	<50	<50	<50	<50	<50	<50	<50	NR	<50	NR	<50	<50	NR	<50	2000	<50	<50	<50	<50	<50		
	E	NR	NR	<50	<50	<50	<50	<50	<50	<50	120	<50	<50	<50	<50	<50	NR	NR	NR	NR	<50	<50	<50	<50	<50	<50	<50	50	50
246 Trichlorophenol	I	NR	NR	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NR	<50	NR	<50	<50	NR	<50	400	<50	<50	<50	<50	<50		
	E	NR	NR	<50	NR	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	NR	NR	NR	NR	<50	<50	<50	<50	<50	<50	<50	50	50
Pentachlorophenol *	I	NR	NR	130	<50	180	<50	100	90	<50	230	230	90	75	NR	<50	NR	<50	<50	NR	850	475	250	100	1000	53	130		
	E	NR	NR	<50	<50	90	<50	<50	80	<50	160	<50	80	350	220	<50	NR	NR	NR	NR	290	110	200	210	200	80	180	50	50

Notes: NR = No Result (data not available)
Units: Liquid Fraction = ng/L
Solid Fraction = ng/g

* = Mass balance calculations performed for these compounds only, the majority of the data for the remaining compounds being at the analytical limit.

TABLE B-23. PHASE 2 RESULTS OF G-BHC, TOTAL PCB's AND PCP ANALYSES FOR SOLID AND LIQUID FRACTIONS OF WPCP IN-PLANT RETURN

COMPOUND	SAMPLE FRACTION	JAN 5-6 1983	JAN 11-12 1983	JAN 18-19 1983	JAN 25-26 1983	APR 13-14 1983	APR 26-27 1983	JULY 11-12 1983	AUG 2-3 1983
G-BHC	Solid	<1	<1	<1	<1	NR	<1	<1	<1
	Liquid	24	74	NR	<1	<1	15	3	5
Total PCB's	Solid	770	125	100	270	NR	50	<20	1245
	Liquid	220	<20	NR	550	<20	40	150	<20
Pentachlorophenol (PCP)	Solid	<50	<50	330	<50	NR	<50	<50	230
	Liquid	<50	NR	90	<50	NR	NR	300	<50

Notes:

G-BHC = Gamma Hexachlorocydohexane
PCB's = Polychlorinated Biphenyls
PCP = Pentachlorophenol
Concentrations expressed in ng/L.

TABLE B-24. PHASE 2 OF METALS ANALYSES FOR SOLID AND LIQUID FRACTIONS OF WPCP INFLUENT AND EFFLUENT

METAL		DEC 6-7/82		DEC 20-21/82		JAN 5-6/83		JAN 11-12/83		JAN 18-19/83		JAN 25-26/83		APR 13-14/83		APR 21-22/83		APR 26-27/83		MAY 2-3/83		JUNE 22-23/83		JULY 11-12/83		AUG 2-3/83		AUG 8-9/83	
		S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
IRON	INF	32000	NR	M	M	27000	1.2	30000	1.7	42000	2.9	58000	1.9	432400	<0.1	36660	<9.0	34780	2.3	51700	1.1	NR	NR	2538	1.6	52450	2.1	28200	1.2
	EFF	37000	NR	0	0	18000	0.12	21000	0.18	30000	0.17	31000	0.11	25380	0.1	29850	0.75	27260	0.08	28200	<0.01	NR	NR	1880	1.7	31020	0.1	25850	0.14
ALUMINUM	INF	8000	0.43	|	|	9100	2.8	9400	0.91	5400	0.37	8500	0.37	8960	0.38	5488	0.52	7280	0.23	9520	4.7	2856	0.15	560	0.38	8960	0.68	8400	0.52
	EFF	8100	0.22	|	|	5800	0.13	6300	0.20	6600	0.20	260	0.18	11060	0.18	6004	0.75	5451	0.21	6636	0.19	3081	0.11	403	0.81	7900	0.50	6557	0.38
ARSENIC	INF	8.51	<0.03	D	D	18.6	<0.03	15.6	<0.03	NR	<0.03	NR	NR	2.12	<0.03	1.31	<0.03	16.2	<0.03	32.3	<0.03	11.6	<0.03	2.1	<0.03	22.2	<0.03	24.2	<0.03
	EFF	12.90	<0.03	A	A	16.4	<0.03	NR	<0.03	9.23	<0.03	9.51	NR	2.75	<0.03	2.24	<0.03	2.06	<0.03	25.8	<0.03	2.75	<0.03	18.9	<0.03	31.0	<0.03	10.3	<0.03
CALCIUM	INF	28000	87	T	T	29000	63	33000	80	25000	75	28000	79	31350	82	17600	91	28050	74	38500	76	NR	NR	2090	68	29150	87	28600	71
	EFF	29000	72	A	A	20000	65	23000	74	24000	71	24000	75	27380	73	22940	79	21460	72	25160	50	NR	NR	1554	76	25900	91	20720	61
CADMIUM	INF	6.40	<0.01	|	|	6.30	<0.01	3.7	<0.01	6.4	<0.01	4.6	<0.01	4.84	<0.01	4.84	<0.01	7.48	<0.01	5.72	<0.01	3.56	<0.01	0.88	<0.06	6.2	<0.01	6.2	0.01
	EFF	13.00	<0.01	|	|	4.80	<0.01	5.1	<0.01	6.4	<0.01	5.6	<0.01	6.6	<0.01	4.62	<0.01	4.62	<0.01	5.62	<0.01	5.48	<0.01	0.66	<0.01	6.6	<0.01	5.94	<0.01
CHROMIUM	INF	770.0	0.10	|	|	660.0	0.02	720.0	0.06	630	0.04	1000	0.06	592	0.02	407	<0.05	481	0.03	999	0.06	244	0.01	111	0.13	2553	0.21	1332	0.12
	EFF	1200.0	0.01	|	|	610.0	<0.01	580.0	0.01	790	<0.01	910	<0.01	816	<0.01	528	<0.02	528	<0.01	576	<0.01	422	<0.01	57.6	0.03	1248	0.06	1152	0.01
COPPER	INF	640.0	0.01	|	|	720.0	0.02	580.0	0.04	580	0.03	620	0.02	706	<0.05	454	<0.16	655	0.08	655	0.04	217	0.01	50.4	0.02	554	0.02	756	0.03
	EFF	650.0	0.01	|	|	490.0	<0.01	470.0	0.03	510	0.01	480	<0.01	688	0.01	448	0.04	512	0.01	520	<0.01	296	<0.01	39.2	0.03	456	0.01	496	0.02
MERCURY	INF	1.40	0.05	|	|	2.8	0.17	1.10	0.04	NR	0.06	1.4	0.06	1.39	0.04	1.07	0.04	1.7	0.07	1.7	0.03	NR	0.07	2.03	0.09	2.11	0.1	NR	0.1
	EF	0.64	<0.02	|	|	1.4	0.03	NR	<0.02	1.3	0.04	1.1	<0.02	1.32	0.01	1.15	0.02	0.99	0.04	1.48	0.02	NR	0.07	1.32	0.08	2.47	0.1	NR	0.05
MAGNESIUM	INF	5200	24.0	|	|	4800	17.0	5200	20	3700	18	5800	160	5720	23	2652	41	4160	18	8840	22	NR	NR	296	17	4420	19	3952	16
	EFF	6800	20.0	|	|	4600	18.0	5300	19	5100	160	4800	160	6290	21	4440	20	5922	18	5624	13	NR	NR	333	16	7030	21	4810	15
NICKEL	INF	160.0	0.05	|	|	230	0.09	330	0.05	250	0.07	360	0.06	139	0.05	267	<0.05	228	0.05	297	0.05	317	0.04	50	0.07	248	0.05	248	0.05
	EFF	170.0	0.04	|	|	140	0.03	150	0.03	210	0.06	210	0.05	221	0.04	162	<0.05	162	0.04	176	0.02	147	0.04	19	0.06	221	0.06	182	0.02
LEAD	INF	580.0	<0.04	|	|	420	<0.04	520	<0.04	440	<0.04	450	0.05	442	0.04	344	<0.04	442	<0.04	772	<0.04	325	0.01	91	<0.04	435	<0.04	618	0.02
	EFF	590.0	<0.01	|	|	260	<0.01	310	<0.01	200	0.01	290	<0.01	429	0.01	264	0.01	278	<0.01	337	<0.01	164	<0.01	27	<0.04	392	<0.01	283	<0.01
SELENIUM	INF	11.45	<0.03	|	|	9.52	<0.03	15.6	<0.03	NR	<0.03	NR	NR	0.48	<0.03	1.02	<0.03	10.9	<0.03	26.5	<0.03	11.3	<0.03	1.7	<0.03	17.7	<0.03	14.3	<0.03
	EFF	51.60	<0.03	|	|	7.54	<0.03	NR	<0.03	24	<0.03	27.1	NR	1.05	<0.03	0.24	12	2.92	<0.03	37.5	<0.03	20.4	<0.03	34.8	<0.03	38.9	<0.03	32.4	<0.03
ZINC	INF	2200	0.12	|	|	1600	0.07	1700	0.16	1400	0.15	1400	0.09	1470	0.04	1276	40	1519	0.16	3136	0.25	951	0.13	250	0.23	1813	0.24	1519	0.18
	EFF	3100	0.03	|	|	1200	0.02	1600	0.05	1600	0.05	1400	0.05	2030	0.07	1260	0.14	1330	0.05	1890	0.07	910	0.11	105	0.14	1470	0.10	1330	0.10

Units: For Solid Fraction - ug/g dry weight basis
For Liquid Fraction - ug/L except in the case of Mercury for which data is reported in ug/L

Notes: NR = No Result (data not available)
Metals data for the solids fraction for the period April - Aug. was originally reported by M.E on a wet weight basis whereas all previous data was reported on a dry weight basis. Therefore, conversion factors were used to convert the data reported on a wet weight basis to a dry weight basis.
No results have been reported for cobalt because the metal was present at concentrations below the detection lim when results were expressed on a wet weight basis.

TABLE B-25. PHASE 2 RESULTS OF METALS ANALYSES FOR SOLID AND LIQUID FRACTIONS OF WPCP INPLANT RETURN

METAL	JAN 5-6/83		JAN 11-12/83		JAN 18-19/83		JAN 25-26/83		APR 13-14/83		APR 26-27/83		JULY 11-12/83		AUG 2-3/83	
	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Iron	41000	3.7	31000	6.4	37000	12.0	36000	5.9	32640	5.2	36720	4.6	2244	3.8	39270	3.4
Aluminum	12000	0.5	8200	1.0	8700	1.6	8700	1.0	11360	1.5	7100	0.42	483	0.63	9940	0.48
Arsenic	12.1	<0.03	13.7	<0.03	NR	<0.03	12.7	NR	1.9	<0.03	2.0	<0.03	15.2	<0.03	32.3	<0.03
Calcium	44000	93	31000	97	35000	110	32000	85	38000	100	31920	99	2204	82	36480	100
Cadmium	9.6	<0.01	5.9	<0.01	7.3	<0.01	7.5	<0.01	6.2	<0.01	6.2	<0.01	0.5	<0.005	10.4	<0.005
Chromium	1400	0.05	850	0.15	980	0.28	1100	0.17	950	0.18	750	0.04	70	0.08	1550	0.06
Copper	750	0.02	580	0.01	620	0.13	620	0.09	686	0.06	650	0.03	43	0.02	606	<0.01
Mercury	1.8	0.09	1.5	0.17	NR	0.29	1.4	0.19	1.4	0.13	1.2	0.06	1.9	0.14	2.0	0.16
Magnesium	8400	25	6700	26	6900	30	6000	24.0	8030	34.0	5548	27	402	21	7300	25
Nickel	240	0.08	190	0.07	240	0.12	270	0.11	230	0.07	192	0.09	21.8	0.11	282	0.07
Lead	700	0.03	430	0.07	470	0.12	420	0.06	452	0.05	409	<0.04	43.5	<0.04	653	<0.04
Selenium	24.7	<0.03	20.7	<0.03	NR	<0.03	20	NR	1.2	0.03	3.6	0.05	37	0.04	45	0.04
Zinc	3100	0.08	2100	0.27	2200	0.49	2000	0.25	2436	0.13	2184	0.09	160	0.13	2436	0.11

Notes: NR = No Result
S = Solid Fraction (ug/g dry weight basis)
L = Liquid Fraction (mg/L except for Mercury for which data is reported in ug/L)

TABLE B - 26 INFLUENT AND EFFLUENT LEVELS OF NAPHTHALENE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	10.77	2.75	1.02	0.0	0.0	2.75	1.02	28.00	0.77	0.02	0.0080	0.0	0.0	0.02	0.0080	99.22	9999.0	99.22
Dec.20-21	287382.0	201.0	592.3	119.1	34.21	0.0	0.0	119.1	34.21	59.10	0.77	0.05	0.01	0.63	0.18	0.68	0.19	99.96	8888.0	8888.0
Jan.5-6	270130.0	165.0	9.23	1.52	0.41	0.0	0.0	1.52	0.41	14.00	0.77	0.01	0.0029	0.0	0.0	0.01	0.0029	99.29	9999.0	99.29
Jan.11-12	303726.0	240.0	7.69	1.85	0.56	0.0	0.0	1.85	0.56	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	9999.0	100.00
Jan.18-19	233810.0	211.0	6.15	1.30	0.30	0.0	0.0	1.30	0.30	22.00	0.77	0.02	0.0040	0.0	0.0	0.02	0.0040	98.70	9999.0	98.70
Jan.25-26	272854.0	249.0	4.62	1.15	0.31	0.0	0.0	1.15	0.31	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	9999.0	100.00
WINTER AVERAGE	289727.7	220.2	105.1	21.27	6.14	0.0	0.0	21.27	6.14	26.02	0.51	0.02	0.0047	0.11	0.03	0.12	0.03	99.53	9999.0	99.44
Apr.13-14	353646.0	199.0	6.15	1.22	0.43	3.80	1.34	5.02	1.78	9.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.21-22	286474.0	211.0	4.62	0.97	0.28	5.06	1.45	6.04	1.73	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.26-27	290106.0	249.0	3.08	0.77	0.22	11.39	3.31	12.16	3.53	7.00	0.0	0.0	0.0	0.63	0.18	0.63	0.18	100.00	94.44	94.79
May.2-3	358206.0	180.0	3.08	0.55	0.20	1.27	0.45	1.82	0.65	20.20	0.0	0.0	0.0	0.63	0.23	0.63	0.23	100.00	50.00	65.22
SPRING AVERAGE	322113.0	209.0	4.23	0.88	0.28	5.38	1.64	6.26	1.92	10.55	0.0	0.0	0.0	0.32	0.10	0.32	0.10	100.00	86.11	90.00
Jun.22-23	284284.0	250.0	0.77	0.19	0.05	0.63	0.18	0.83	0.23	11.00	0.77	0.0085	0.0024	0.63	0.18	0.64	0.18	95.60	9999.0	9999.0
Jul.11-12	268768.0	96.00	4.62	0.45	0.12	3.80	1.02	4.24	1.14	10.30	0.0	0.0	0.0	0.63	0.17	0.63	0.17	100.00	83.33	85.09
Aug.2-3	276032.0	137.0	4.62	0.63	0.17	15.19	4.19	15.82	4.37	5.70	3.08	0.02	0.0048	0.63	0.17	0.65	0.18	97.23	95.83	95.89
Aug.8-9	314622.0	102.0	3.08	0.56	0.18	13.92	4.38	14.48	4.56	12.60	1.54	0.02	0.0061	0.0	0.0	0.02	0.0061	96.54	100.00	99.87
SUMMER AVERAGE	285906.5	166.5	3.27	0.46	0.13	8.39	2.44	8.84	2.57	9.90	1.35	0.01	0.0033	0.47	0.13	0.49	0.13	97.34	93.06	93.61
OVERALL AVERAGE	297888.9	201.8	47.20	9.50	2.75	3.93	1.17	13.43	3.91	16.99	0.60	0.01	0.0029	0.27	0.08	0.28	0.08	99.04	89.89	94.84
MAXIMUM	370464.0	255.0	592.3	119.1	34.21	15.19	4.38	119.1	34.21	59.10	3.08	0.05	0.01	0.63	0.23	0.68	0.23	100.00	100.00	100.00
MINIMUM	233810.0	96.00	0.77	0.19	0.05	0.0	0.0	0.83	0.23	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.60	50.00	65.22

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE / INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 27 INFLUENT AND EFFLUENT LEVELS OF ACENAPHTHYLENE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	9.64	2.46	0.91	3.26	1.21	5.72	2.12	28.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Dec.20-21	287382.0	201.0	83.13	16.71	4.80	21.74	6.25	38.45	11.05	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Jan.5-6	270130.0	165.0	15.66	2.58	0.70	6.52	1.76	9.11	2.46	14.00	0.60	0.0004	0.0023	0.0	0.0	0.0004	0.0023	99.67	100.00	99.91
Jan.11-12	303726.0	240.0	13.25	3.18	0.97	1.09	0.33	4.27	1.30	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Jan.18-19	233810.0	211.0	9.64	2.03	0.48	3.26	0.76	5.29	1.24	22.00	0.60	0.01	0.0031	0.0	0.0	0.01	0.0031	99.35	100.00	99.75
Jan.25-26	272854.0	249.0	9.64	2.40	0.65	3.26	0.89	5.66	1.54	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
WINTER																				
AVERAGE	289727.7	220.2	23.49	4.89	1.42	6.52	1.87	11.42	3.28	26.02	0.20	0.0036	0.0009	0.0	0.0	0.0036	0.0009	99.84	100.00	99.94
																				#
Apr.13-14	353666.0	199.0	4.82	0.96	0.34	3.26	1.15	4.22	1.49	9.00	2.41	0.02	0.0077	0.0	0.0	0.02	0.0077	97.74	100.00	99.49
Apr.21-22	286474.0	211.0	0.60	0.13	0.04	1.09	0.31	1.21	0.35	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.26-27	290106.0	249.0	0.60	0.15	0.04	0.54	0.16	0.69	0.20	7.00	0.0	0.0	0.0	0.54	0.16	0.54	0.16	100.00	9999.0	9999.0
Aug.2-3	358206.0	180.0	0.0	0.0	0.0	0.54	0.19	0.54	0.19	20.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9999.0	100.00	100.00
SPRING																				
AVERAGE	322397.5	209.0	1.51	0.31	0.10	1.36	0.45	1.67	0.56	10.55	0.60	0.0054	0.0019	0.14	0.04	0.14	0.04	99.25	100.00	99.83
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.54	0.15	0.54	0.15	11.00	0.60	0.0066	0.0019	0.0	0.0	0.0066	0.0019	8888.0	100.00	8888.0
Jul.11-12	268768.0	96.00	0.0	0.0	0.0	0.54	0.15	0.54	0.15	10.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9999.0	100.00	100.00
Aug.2-3	276032.0	137.0	7.23	0.99	0.27	2.17	0.60	3.16	0.87	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Aug.8-9	314622.0	182.0	0.60	0.11	0.03	1.09	0.34	1.20	0.38	12.60	0.60	0.0076	0.0024	0.0	0.0	0.0076	0.0024	93.08	100.00	99.37
SUMMER																				
AVERAGE	285906.5	166.5	1.96	0.28	0.08	1.09	0.31	1.36	0.39	9.90	0.30	0.0036	0.0011	0.0	0.0	0.0036	0.0011	96.54	100.00	99.79
OVERALL																				
AVERAGE	297888.9	201.8	11.06	2.26	0.66	3.49	1.02	5.76	1.68	16.99	0.34	0.0041	0.0012	0.04	0.01	0.04	0.01	99.08	100.00	99.88
MAXIMUM	370464.0	255.0	83.13	16.71	4.80	21.74	6.25	38.45	11.05	59.10	2.41	0.02	0.0077	0.54	0.16	0.54	0.16	100.00	100.00	100.00
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.54	0.15	0.54	0.15	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.08	100.00	99.37

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 28 INFLUENT AND EFFLUENT LEVELS OF DIBENZOFURAN AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	9.52	2.43	0.90	0.99	0.37	3.42	1.27	28.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Dec.20-21	287382.0	201.0	307.1	61.74	17.74	53.47	15.36	115.2	33.11	59.10	0.0	0.0	0.0	0.99	0.28	0.99	0.28	100.00	98.15	99.14
Jan.5-6	270130.0	165.0	15.40	2.55	0.69	1.98	0.53	4.53	1.22	14.00	0.60	0.0003	0.0023	0.0	0.0	0.0003	0.0023	99.47	100.00	99.82
Jan.11-12	303726.0	240.0	13.10	3.14	0.95	1.98	0.60	5.12	1.56	21.00	5.95	0.13	0.04	0.0	0.0	0.13	0.04	96.02	100.00	97.56
Jan.18-19	233810.0	211.0	0.33	1.76	0.41	1.98	0.46	3.74	0.87	22.00	0.60	0.01	0.0031	0.0	0.0	0.01	0.0031	99.26	100.00	99.65
Jan.25-26	272854.0	249.0	16.67	4.15	1.13	1.98	0.54	6.13	1.67	12.00	0.60	0.0071	0.0019	0.0	0.0	0.0071	0.0019	99.83	100.00	99.88
WINTER AVERAGE	289727.7	220.2	61.71	12.63	3.64	10.40	2.98	23.02	6.62	26.02	1.29	0.03	0.0075	0.17	0.05	0.19	0.05	99.13	99.69	99.34
Apr.13-14	353666.0	199.0	5.95	1.18	0.42	0.99	0.35	2.17	0.77	9.00	3.57	0.03	0.01	0.0	0.0	0.03	0.01	97.29	100.00	98.52
Apr.21-22	286474.0	211.0	4.76	1.00	0.29	0.99	0.28	1.99	0.57	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.26-27	290106.0	249.0	0.0	0.0	0.0	0.99	0.29	0.99	0.29	7.00	0.0	0.0	0.0	0.50	0.14	0.50	0.14	9999.0	50.00	50.00
May.2-3	358206.0	180.0	0.60	0.11	0.04	0.99	0.35	1.10	0.39	20.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
SPRING AVERAGE	322412.6	209.8	2.83	0.57	0.19	0.99	0.32	1.56	0.51	10.55	0.89	0.0080	0.0028	0.12	0.04	0.13	0.04	99.10	87.50	87.13
Jun.22-23	284204.0	250.0	2.38	0.60	0.17	0.99	0.28	1.59	0.45	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Jul.11-12	268760.0	96.00	4.76	0.46	0.12	1.98	0.53	2.44	0.66	10.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Aug.2-3	274032.0	137.0	5.95	0.82	0.23	1.98	0.55	2.80	0.77	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Aug.8-9	314422.0	182.0	3.57	0.65	0.20	0.99	0.31	1.64	0.52	12.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
SUMMER AVERAGE	285996.5	166.5	4.17	0.63	0.18	1.49	0.42	2.12	0.60	9.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
OVERALL AVERAGE	297888.9	201.8	28.44	5.76	1.66	5.16	1.49	10.92	3.15	16.99	0.81	0.01	0.0040	0.11	0.03	0.12	0.03	99.39	96.30	96.04
MAXIMUM	370464.0	255.0	307.1	61.74	17.74	53.47	15.36	115.2	33.11	59.10	5.95	0.13	0.04	0.99	0.28	0.99	0.28	100.00	100.00	100.00
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.99	0.28	0.99	0.29	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.02	50.00	50.00

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 29 INFLUENT AND EFFLUENT LEVELS OF FLUORENE AT HAMILTON RPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ng/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	13.79	3.52	1.30	2.02	0.75	5.54	2.05	20.00	0.57	0.02	0.0060	0.0	0.0	0.02	0.0060	99.54	100.00	99.71
Dec.20-21	287382.0	201.0	452.9	91.03	26.16	63.44	18.29	154.7	44.45	59.10	0.57	0.03	0.0098	2.02	0.58	2.05	0.59	99.96	96.83	98.67
Jan.5-6	270130.0	165.0	16.09	2.66	0.72	3.03	0.82	5.69	1.54	14.00	0.57	0.0080	0.0022	0.0	0.0	0.0080	0.0022	99.70	100.00	99.86
Jan.11-12	303726.0	240.0	18.39	4.41	1.34	2.02	0.61	6.43	1.95	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Jan.18-19	233810.0	211.0	16.09	3.40	0.79	2.02	0.47	5.42	1.27	22.00	0.57	0.01	0.0030	0.0	0.0	0.01	0.0030	99.63	100.00	99.77
Jan.25-26	272854.0	249.0	18.39	4.58	1.25	4.04	1.10	8.62	2.35	12.00	0.57	0.0069	0.0019	0.0	0.0	0.0069	0.0019	99.85	100.00	99.92
WINTER AVERAGE	289727.7	220.2	89.27	18.26	5.26	12.79	3.67	31.06	8.93	26.02	0.48	0.01	0.0038	0.34	0.10	0.35	0.10	99.78	99.47	99.65
Apr.13-14	353666.0	199.0	8.05	1.60	0.57	1.01	0.36	2.61	0.92	9.00	2.30	0.02	0.0073	0.0	0.0	0.02	0.0073	98.71	100.00	99.21
Apr.21-22	286474.0	211.0	5.75	1.21	0.35	1.01	0.29	2.22	0.64	6.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.26-27	290106.0	249.0	2.30	0.57	0.17	1.01	0.29	1.58	0.46	7.00	0.0	0.0	0.0	0.51	0.15	0.51	0.15	100.00	50.00	68.09
May.2-3	358206.0	180.0	2.30	0.41	0.15	1.01	0.36	1.42	0.51	20.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
SPRING AVERAGE	322449.1	209.8	4.60	0.95	0.31	1.01	0.33	1.96	0.63	10.55	0.57	0.0052	0.0018	0.13	0.04	0.13	0.04	99.48	87.50	91.82
Jun.22-23	284204.0	250.0	8.05	2.01	0.57	1.01	0.29	3.02	0.86	11.00	0.57	0.0063	0.0018	0.0	0.0	0.0063	0.0018	99.69	100.00	99.79
Jul.11-12	268768.0	96.00	8.05	0.78	0.21	1.01	0.27	1.79	0.48	10.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Aug.2-3	276032.0	137.0	4.60	0.63	0.17	1.01	0.28	1.64	0.45	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Aug.8-9	314622.0	182.0	4.60	0.84	0.26	1.01	0.32	1.85	0.58	12.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
SUMMER AVERAGE	285906.5	166.5	6.32	1.06	0.30	1.01	0.29	2.07	0.59	9.90	0.14	0.0016	0.0004	0.0	0.0	0.0016	0.0004	99.92	100.00	99.95
OVERALL AVERAGE	297888.9	201.0	41.30	8.40	2.43	6.06	1.75	14.46	4.18	16.99	0.41	0.0075	0.0023	0.18	0.05	0.19	0.05	99.79	96.28	97.50
MAXIMUM	370464.0	255.0	452.9	91.03	26.16	63.44	18.29	154.7	44.45	59.10	2.30	0.03	0.0098	2.02	0.58	2.05	0.59	100.00	100.00	100.00
MINIMUM	233810.0	96.00	2.30	0.41	0.15	1.01	0.27	1.42	0.45	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.71	50.00	68.09

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 30 INFLUENT AND EFFLUENT LEVELS OF FLUORANTHENE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	25.27	6.45	2.39	0.94	0.35	7.39	2.74	28.00	26.37	0.74	0.27	0.47	0.17	1.21	0.45	88.54	50.00	83.62
Dec.20-21	287302.0	201.0	1684.6	338.6	97.31	80.19	23.04	418.8	120.4	59.10	45.05	2.66	0.77	0.47	0.14	3.13	0.90	99.21	99.41	99.25
Jan.5-6	270130.0	165.0	84.62	13.96	3.77	2.83	0.76	16.79	4.54	14.00	68.13	0.95	0.26	0.47	0.13	1.43	0.39	93.17	83.33	91.51
Jan.11-12	303726.0	240.0	84.62	20.31	6.17	2.83	0.86	23.14	7.03	21.00	45.05	0.95	0.29	0.0	0.0	0.95	0.29	95.34	100.00	95.91
Jan.18-19	233810.0	211.0	83.52	17.62	4.12	2.83	0.66	20.45	4.78	22.00	27.47	0.60	0.14	0.0	0.0	0.60	0.14	96.57	100.00	97.06
Jan.25-26	272854.0	249.0	40.66	10.12	2.76	0.94	0.26	11.07	3.02	12.00	19.78	0.24	0.06	0.0	0.0	0.24	0.06	97.66	100.00	97.86
WINTER AVERAGE	289727.7	220.2	333.9	67.84	19.42	15.09	4.32	82.94	23.74	26.02	38.64	1.02	0.30	0.24	0.07	1.26	0.37	95.08	88.79	94.20
Apr.13-14	353666.0	199.0	26.37	5.25	1.86	0.94	0.33	6.19	2.19	9.00	24.18	0.22	0.08	0.0	0.0	0.22	0.08	95.85	100.00	96.49
Apr.21-22	286474.0	211.0	25.27	5.33	1.53	0.94	0.27	6.28	1.80	6.00	17.58	0.11	0.03	0.0	0.0	0.11	0.03	98.02	100.00	98.32
Apr.26-27	290106.0	249.0	19.70	4.93	1.43	0.94	0.27	5.87	1.70	7.00	14.29	0.10	0.03	0.0	0.0	0.10	0.03	97.97	100.00	98.30
Aug.2-3	350206.0	180.0	18.48	3.36	1.20	0.47	0.17	3.83	1.37	20.20	10.99	0.22	0.08	0.0	0.0	0.22	0.08	93.40	100.00	94.21
SPRING AVERAGE	322456.3	209.8	22.53	4.72	1.50	0.83	0.26	5.54	1.77	10.55	16.76	0.16	0.05	0.0	0.0	0.16	0.05	96.31	100.00	96.83
Jun.22-23	284294.0	250.0	29.67	7.42	2.11	0.94	0.27	8.36	2.38	11.00	6.59	0.07	0.02	0.0	0.0	0.07	0.02	99.02	100.00	99.13
Jul.11-12	268768.0	96.80	23.08	2.23	0.60	0.94	0.25	3.18	0.85	10.30	4.40	0.05	0.01	0.0	0.0	0.05	0.01	97.97	100.00	98.58
Aug.2-3	276932.0	137.0	25.27	3.46	0.96	0.94	0.26	4.41	1.22	5.70	15.38	0.09	0.02	0.0	0.0	0.09	0.02	97.47	100.00	98.01
Aug.8-9	314622.0	182.0	23.08	4.20	1.32	1.89	0.59	6.09	1.92	12.60	10.99	0.14	0.04	0.0	0.0	0.14	0.04	98.70	100.00	97.73
SUMMER AVERAGE	285906.5	166.5	25.27	4.33	1.25	1.18	0.34	5.51	1.59	9.90	9.34	0.09	0.03	0.0	0.0	0.09	0.03	97.79	100.00	98.36
OVERALL AVERAGE	297088.9	201.8	156.8	31.66	9.11	7.04	2.03	38.70	11.13	16.99	24.02	0.51	0.15	0.10	0.03	0.61	0.18	96.21	95.20	96.14
MAXIMUM	370464.0	255.0	1684.6	338.6	97.31	80.19	23.04	418.8	120.4	59.10	68.13	2.66	0.77	0.47	0.17	3.13	0.90	99.21	100.00	99.25
MINIMUM	233810.0	96.80	18.48	2.23	0.60	0.47	0.17	3.18	0.85	5.70	4.40	0.05	0.01	0.0	0.0	0.05	0.01	88.54	50.00	83.62

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 31 INFLUENT AND EFFLUENT LEVELS OF CARBAZOLE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370444.0	255.0	20.00	5.10	1.89	3.85	1.42	8.95	3.31	28.00	10.59	0.30	0.11	0.0	0.0	0.30	0.11	94.19	100.00	96.69
Dec.20-21	287302.0	201.0	124.7	25.07	7.20	50.96	14.65	76.03	21.85	59.10	14.12	0.83	0.24	0.0	0.0	0.83	0.24	96.67	100.00	98.90
Jan.5-6	270130.0	165.0	23.53	3.88	1.05	6.73	1.82	10.41	2.87	14.00	29.41	0.41	0.11	0.0	0.0	0.41	0.11	89.39	100.00	96.12
Jan.11-12	303726.0	240.0	20.00	4.00	1.46	2.00	0.00	7.60	2.33	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Jan.18-19	233810.0	211.0	29.41	6.21	1.45	8.65	2.02	14.06	3.47	22.00	21.18	0.47	0.11	0.0	0.0	0.47	0.11	92.49	100.00	96.84
Jan.25-26	272854.0	249.0	44.71	11.13	3.04	3.85	1.05	14.90	4.09	12.00	17.65	0.21	0.06	0.0	0.0	0.21	0.06	98.10	100.00	98.59
WINTER																				
AVERAGE	289727.7	220.2	43.73	9.36	2.60	12.02	3.64	22.10	6.32	26.02	15.49	0.37	0.10	0.0	0.0	0.37	0.10	95.14	100.00	97.86
Apr.13-14	353666.0	199.0	32.94	6.56	2.32	4.81	1.70	11.36	4.02	9.00	48.24	0.43	0.15	0.0	0.0	0.43	0.15	93.38	100.00	96.18
Apr.21-22	286474.0	211.0	47.06	9.93	2.84	10.58	3.03	20.51	5.87	6.00	28.24	0.17	0.05	0.0	0.0	0.17	0.05	98.29	100.00	99.17
Apr.26-27	290186.0	249.0	47.06	11.72	3.40	16.33	4.74	28.06	8.14	7.00	37.18	0.26	0.08	0.48	0.14	0.74	0.22	97.75	97.06	97.35
Aug.2-3	358286.0	180.0	41.18	7.41	2.65	9.62	3.44	17.03	6.10	20.20	29.41	0.59	0.21	0.48	0.17	1.07	0.39	91.98	95.00	93.69
SPRING																				
AVERAGE	322449.5	209.8	42.06	8.90	2.80	10.34	3.23	19.24	6.03	10.55	35.88	0.37	0.12	0.24	0.08	0.61	0.20	95.35	98.01	96.60
Jun.22-23	284284.0	250.0	48.24	12.06	3.43	9.62	2.73	21.67	6.16	11.00	22.35	0.25	0.07	0.0	0.0	0.25	0.07	97.96	100.00	98.87
Jul.11-12	268768.0	96.00	37.65	3.64	0.98	19.23	5.17	22.88	6.15	10.30	17.65	0.18	0.05	0.0	0.0	0.18	0.05	95.01	100.00	99.21
Aug.2-3	274032.0	137.0	36.47	5.00	1.38	19.23	5.31	24.23	6.69	5.70	27.06	0.15	0.04	0.0	0.0	0.15	0.04	96.91	100.00	99.36
Aug.8-9	314622.0	182.0	41.18	7.49	2.36	16.35	5.14	23.84	7.50	12.60	38.82	0.49	0.15	0.0	0.0	0.49	0.15	93.47	100.00	97.95
SUMMER																				
AVERAGE	285906.5	166.5	40.88	7.05	2.04	16.11	4.59	23.15	6.62	9.90	26.47	0.27	0.08	0.0	0.0	0.27	0.08	95.84	100.00	98.85
OVERALL																				
AVERAGE	297888.9	201.8	42.44	8.57	2.53	13.65	3.79	21.62	6.33	16.99	24.45	0.34	0.10	0.07	0.02	0.41	0.12	95.40	99.43	97.70
MAXIMUM	370444.0	255.0	124.7	25.07	7.20	50.96	14.65	76.03	21.85	59.10	48.24	0.83	0.24	0.48	0.17	1.07	0.39	100.00	100.00	100.00
MINIMUM	233810.0	96.00	20.00	3.64	0.98	2.00	0.00	7.60	2.33	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	89.39	95.00	93.69

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 32 INFLUENT AND EFFLUENT LEVELS OF PYRENE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	24.24	6.18	2.29	0.96	0.36	7.14	2.65	20.00	24.24	0.68	0.25	0.48	0.18	1.16	0.43	89.02	50.00	83.77
Dec.20-21	287302.0	201.0	1575.8	316.7	91.02	62.50	17.96	379.2	109.0	59.10	75.76	4.48	1.29	0.48	0.14	4.96	1.42	98.59	99.23	98.69
Jan.5-6	270130.0	165.0	68.18	11.25	3.04	1.92	0.52	13.17	3.56	14.00	89.39	1.25	0.34	0.48	0.13	1.73	0.47	88.88	75.00	86.85
Jan.11-12	303726.0	240.0	71.21	17.09	5.19	2.88	0.88	19.98	6.07	21.00	43.94	0.92	0.28	0.0	0.0	0.92	0.28	94.60	100.00	95.38
Jan.18-19	233810.0	211.0	83.33	17.58	4.11	1.92	0.45	19.51	4.56	22.00	34.85	0.77	0.18	0.0	0.0	0.77	0.18	95.64	100.00	96.07
Jan.25-26	272854.0	249.0	45.45	11.32	3.09	0.96	0.26	12.28	3.35	12.00	27.27	0.33	0.09	0.0	0.0	0.33	0.09	97.11	100.00	97.33
WINTER AVERAGE	289727.7	220.2	311.4	63.36	18.12	11.86	3.40	75.22	21.53	26.02	49.24	1.40	0.40	0.24	0.07	1.64	0.48	93.97	87.37	93.02
Apr.13-14	353666.0	199.0	29.79	5.73	2.03	0.96	0.34	6.69	2.37	9.00	37.88	0.34	0.12	0.0	0.0	0.34	0.12	94.05	100.00	94.98
Apr.21-22	286474.0	211.0	27.27	5.75	1.65	0.96	0.28	6.72	1.92	6.00	22.73	0.14	0.04	0.0	0.0	0.14	0.04	97.63	100.00	97.97
Apr.26-27	290106.0	249.0	19.70	4.90	1.42	0.96	0.28	5.87	1.70	7.00	19.70	0.14	0.04	0.0	0.0	0.14	0.04	97.19	100.00	97.65
May.2-3	358286.0	180.0	21.21	3.82	1.37	0.96	0.34	4.78	1.71	20.20	15.15	0.31	0.11	0.0	0.0	0.31	0.11	91.98	100.00	93.60
SPRING AVERAGE	322455.3	209.8	24.24	5.05	1.62	0.96	0.31	6.01	1.93	10.55	23.86	0.23	0.08	0.0	0.0	0.23	0.08	95.21	100.00	96.03
Jun.22-23	284284.0	250.0	19.70	4.92	1.40	0.96	0.27	5.89	1.67	11.00	7.58	0.08	0.02	0.0	0.0	0.08	0.02	98.31	100.00	98.58
Jul.11-12	268768.0	96.00	21.21	2.05	0.55	0.96	0.26	3.01	0.81	10.30	6.06	0.06	0.02	0.0	0.0	0.06	0.02	96.96	100.00	97.93
Aug.2-3	276032.0	137.0	22.73	3.11	0.86	0.96	0.27	4.08	1.12	5.70	15.15	0.09	0.02	0.0	0.0	0.09	0.02	97.23	100.00	97.88
Aug.8-9	314622.0	182.0	22.73	4.14	1.30	0.96	0.30	5.10	1.60	12.60	12.12	0.15	0.05	0.0	0.0	0.15	0.05	96.31	100.00	97.00
SUMMER AVERAGE	285906.5	166.5	21.59	3.56	1.03	0.96	0.27	4.52	1.30	9.90	10.23	0.10	0.03	0.0	0.0	0.10	0.03	97.20	100.00	97.85
OVERALL AVERAGE	297888.9	201.8	146.5	29.61	8.52	5.63	1.63	35.25	10.15	16.99	30.84	0.70	0.20	0.10	0.03	0.80	0.24	95.25	94.59	95.26
MAXIMUM	370464.0	255.0	1575.8	316.7	91.02	62.50	17.96	379.2	109.0	59.10	89.39	4.48	1.29	0.48	0.18	4.96	1.42	98.59	100.00	98.69
MINIMUM	233810.0	96.00	19.70	2.05	0.55	0.96	0.26	3.01	0.81	5.70	6.06	0.06	0.02	0.0	0.0	0.06	0.02	88.88	50.00	83.77

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - II INFLUENT AND EFFLUENT LEVELS OF BENZO(A)PYRENE AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370444.0	255.0	120.3	30.67	11.36	7.27	2.69	37.94	14.06	28.00	29.73	0.83	0.31	0.45	0.17	1.29	0.48	97.29	93.75	96.61
Dec.20-21	287382.0	201.0	441.9	129.0	37.08	0.0	0.0	129.0	37.08	59.10	17.57	1.04	0.30	0.0	0.0	1.04	0.30	99.20	9999.0	99.20
Jan.5-6	270130.0	165.0	277.0	45.71	12.35	12.73	3.44	58.44	15.79	14.00	77.03	1.08	0.29	0.0	0.0	1.08	0.29	97.[illegible]	100.00	98.15
Jan.11-12	303726.0	240.0	212.2	50.92	15.47	30.00	9.11	80.92	24.58	21.00	128.4	2.70	0.82	0.0	0.0	2.70	0.82	96.71	100.00	96.67
Jan.18-19	233010.0	211.0	135.1	28.51	6.67	16.36	3.83	44.88	10.49	22.00	18.92	0.42	0.10	0.0	0.0	0.42	0.10	98.54	100.00	99.07
Jan.25-26	272854.0	249.0	83.78	20.86	5.69	3.64	0.99	24.50	6.68	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
WINTER AVERAGE	289727.7	220.2	265.0	50.95	14.77	11.67	3.34	62.62	18.11	26.02	45.27	1.01	0.30	0.00	0.03	1.09	0.33	97.89	98.75	98.28
Apr.13-14	353666.0	199.0	114.9	22.84	8.00	7.27	2.57	30.13	10.66	9.00	71.62	0.64	0.23	0.0	0.0	0.64	0.23	97.18	100.00	97.86
Apr.21-22	286474.0	211.0	109.5	23.10	6.62	4.55	1.30	27.64	7.92	6.00	35.14	0.21	0.06	0.0	0.0	0.21	0.06	99.09	100.00	99.24
Apr.26-27	290106.0	249.0	87.04	21.87	6.35	7.27	2.11	29.14	8.45	7.00	28.38	0.20	0.06	0.0	0.0	0.20	0.06	99.09	100.00	99.32
May.2-3	358206.0	180.0	56.76	10.22	3.66	2.73	0.98	12.94	4.64	20.20	18.92	0.38	0.14	0.0	0.0	0.38	0.14	96.26	100.00	97.05
SPRING AVERAGE	322416.4	209.8	92.23	19.51	6.18	5.45	1.74	24.97	7.92	10.55	38.51	0.36	0.12	0.0	0.0	0.36	0.12	97.90	100.00	98.37
Jun.22-23	284204.0	250.0	81.08	20.27	5.76	4.55	1.29	24.82	7.05	11.00	24.32	0.27	0.08	0.0	0.0	0.27	0.08	98.68	100.00	98.92
Jul.11-12	268768.0	96.80	75.68	7.33	1.97	4.55	1.22	11.87	3.19	10.30	14.86	0.15	0.04	0.0	0.0	0.15	0.04	97.91	100.00	98.71
Aug.2-3	276032.0	137.0	104.1	14.26	3.93	10.00	2.76	24.26	6.70	5.70	5.41	0.03	0.0085	0.0	0.0	0.03	0.0085	99.78	100.00	99.87
Aug.8-9	314622.0	182.0	133.8	24.35	7.66	14.55	4.58	38.89	12.24	12.60	18.92	0.24	0.07	0.0	0.0	0.24	0.07	99.02	100.00	99.39
SUMMER AVERAGE	285906.5	166.5	98.65	16.55	4.83	8.41	2.46	24.96	7.29	9.90	15.88	0.17	0.05	0.0	0.0	0.17	0.05	98.85	100.00	99.22
OVERALL AVERAGE	297888.9	201.8	159.6	32.14	9.47	8.94	2.63	41.10	12.11	16.99	34.94	0.58	0.18	0.03	0.01	0.62	0.19	98.17	99.52	98.58
MAXIMUM	370444.0	255.0	441.9	129.0	37.08	30.00	9.11	129.0	37.08	59.10	128.4	2.70	0.82	0.45	0.17	2.70	0.82	100.00	100.00	100.00
MINIMUM	233810.0	96.80	56.76	7.33	1.97	0.0	0.0	11.87	3.19	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.71	93.75	96.61

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 34 INFLUENT AND EFFLUENT LEVELS OF G-BHC (LINDANE) AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370444.0	255.0	0.0	0.0	0.0	0.03	0.01	0.03	0.01	28.80	0.0	0.0	0.0	0.04	0.01	0.04	0.01	9999.0	8888.0	8888.0
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.03	0.0075	0.03	0.0075	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9999.0	100.00	100.00
Jan.5-6	270130.0	165.0	0.0	0.0	0.0	0.26	0.07	0.26	0.07	14.00	0.0	0.0	0.0	0.15	0.04	0.15	0.04	9999.0	43.19	43.19
Jan.11-12	303726.0	240.0	0.0	0.0	0.0	0.25	0.08	0.25	0.08	21.00	0.0	0.0	0.0	0.09	0.03	0.09	0.03	9999.0	64.03	64.03
Jan.18-19	233810.0	211.0	0.0	0.0	0.0	0.17	0.04	0.17	0.04	22.00	0.0	0.0	0.0	0.02	0.0054	0.02	0.0054	9999.0	86.86	86.86
Jan.25-26	272854.0	249.0	0.0	0.0	0.0	0.04	0.0098	0.04	0.0098	12.00	0.0	0.0	0.0	0.0030	0.0008	0.0030	0.0008	9999.0	91.67	91.67
WINTER AVERAGE	289727.7	220.2	0.0	0.0	0.0	0.13	0.04	0.13	0.04	26.02	0.0	0.0	0.0	0.05	0.01	0.05	0.01	9999.0	77.15	77.15
Apr.13-14	353666.0	199.0	0.03	0.0056	0.0020	0.04	0.01	0.05	0.02	9.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	100.00	100.00
Apr.21-22	286474.0	211.0	0.0	0.0	0.0	0.09	0.03	0.09	0.03	6.00	0.01	0.0001	0.0000	0.0	0.0	0.0001	0.0000	8888.0	100.00	8888.0
Apr.26-27	290106.0	249.0	0.0020	0.0005	0.0001	0.28	0.08	0.29	0.08	7.00	0.0	0.0	0.0	0.16	0.05	0.16	0.05	100.00	42.11	42.21
May.2-3	358206.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
SPRING AVERAGE	322458.0	209.8	0.0075	0.0015	0.0005	0.10	0.03	0.11	0.03	10.55	0.0030	0.0000	0.0000	0.04	0.01	0.04	0.01	100.00	80.70	71.10
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jul.11-12	268768.0	96.80	0.0	0.0	0.0	0.01	0.0032	0.01	0.0032	10.30	0.0	0.0	0.0	0.01	0.0027	0.01	0.0027	9999.0	16.67	16.67
Aug.2-3	276032.0	137.0	0.0030	0.0004	0.0001	0.01	0.0039	0.01	0.0040	5.70	0.0	0.0	0.0	0.0020	0.0006	0.0020	0.0006	100.00	85.71	86.12
Aug.8-9	314622.0	182.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
SUMMER AVERAGE	285906.5	166.5	0.0008	0.0001	0.0000	0.0065	0.0018	0.0066	0.0018	9.90	0.0	0.0	0.0	0.0030	0.0008	0.0030	0.0008	100.00	51.19	51.39
OVERALL AVERAGE	297888.9	201.8	0.0024	0.0005	0.0002	0.09	0.02	0.09	0.02	16.99	0.0009	0.0000	0.0000	0.03	0.0099	0.03	0.0099	100.00	73.02	70.08
MAXIMUM	370444.0	255.0	0.03	0.0056	0.0020	0.28	0.08	0.29	0.08	59.10	0.01	0.0001	0.0000	0.16	0.05	0.16	0.05	100.00	100.00	100.00
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	16.67	16.67

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 35 INFLUENT AND EFFLUENT LEVELS OF TOTAL PCB AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	1.20	0.33	0.12	0.07	0.03	0.40	0.15	20.00	2.19	0.06	0.02	0.23	0.09	0.30	0.11	81.21	8888.0	8888.0
Dec.20-21	287382.0	201.0	0.36	0.07	0.02	0.10	0.03	0.10	0.05	59.10	0.35	0.02	0.0059	0.02	0.0072	0.05	0.01	71.43	76.19	74.26
Jan.5-6	270130.0	165.0	0.06	0.0091	0.0025	0.08	0.02	0.09	0.03	16.00	0.0	0.0	0.0	0.02	0.0054	0.02	0.0054	100.00	76.47	78.74
Jan.11-12	303726.0	240.0	0.06	0.01	0.0044	0.0	0.0	0.01	0.0044	21.00	0.04	0.0008	0.0003	0.0	0.0	0.0008	0.0003	94.17	9999.0	94.17
Jan.18-19	233810.0	211.0	0.12	0.03	0.0059	0.0	0.0	0.03	0.0059	22.00	0.10	0.0022	0.0005	0.0	0.0	0.0022	0.0005	91.31	9999.0	91.31
Jan.25-26	272054.0	249.0	0.13	0.03	0.0088	0.10	0.03	0.14	0.04	12.00	0.06	0.0007	0.0002	0.0	0.0	0.0007	0.0002	97.78	100.00	99.48
WINTER AVERAGE	289727.7	220.2	0.33	0.08	0.03	0.06	0.02	0.14	0.05	26.02	0.46	0.01	0.0049	0.05	0.02	0.06	0.02	89.32	84.22	87.59
Apr.13-14	353666.0	199.0	0.53	0.10	0.04	0.0	0.0	0.10	0.04	9.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	9999.0	100.00
Apr.21-22	206474.0	211.0	0.0	0.0	0.0	0.07	0.02	0.07	0.02	6.00	0.20	0.0012	0.0003	0.02	0.0057	0.02	0.0061	8888.0	73.33	8888.0
Apr.26-27	290106.0	249.0	0.26	0.06	0.02	0.05	0.01	0.11	0.03	7.00	0.06	0.0004	0.0001	0.0	0.0	0.0004	0.0001	99.35	100.00	99.62
May.2-3	358206.0	180.0	0.05	0.0081	0.0029	0.0	0.0	0.0081	0.0029	20.20	0.65	0.01	0.0047	0.0	0.0	0.01	0.0047	8888.0	9999.0	8888.0
SPRING AVERAGE	322270.7	209.0	0.21	0.04	0.01	0.03	0.0006	0.07	0.02	10.55	0.23	0.0037	0.0013	0.0050	0.0014	0.0087	0.0027	99.68	86.67	99.81
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.05	0.01	0.05	0.01	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9999.0	100.00	100.00
Jul.11-12	268768.0	96.00	0.98	0.09	0.03	0.03	0.0094	0.13	0.03	10.30	1.65	0.02	0.0046	0.02	0.0054	0.04	0.0099	81.99	42.86	71.41
Aug.2-3	276032.0	137.0	0.95	0.13	0.04	0.05	0.02	0.18	0.05	5.70	1.51	0.0086	0.0024	0.02	0.0055	0.03	0.0079	93.37	63.64	84.51
Aug.8-9	314622.0	182.0	1.41	0.26	0.08	0.05	0.02	0.31	0.10	12.60	1.39	0.02	0.0055	0.0	0.0	0.02	0.0055	93.18	100.00	94.29
SUMMER AVERAGE	285906.5	166.5	0.83	0.12	0.04	0.05	0.01	0.17	0.05	9.90	1.14	0.01	0.0031	0.01	0.0027	0.02	0.0058	89.51	76.62	87.55
OVERALL AVERAGE	297888.9	201.8	0.44	0.08	0.03	0.05	0.01	0.13	0.04	16.99	0.58	0.01	0.0036	0.02	0.0083	0.03	0.01	91.25	81.39	89.80
MAXIMUM	370464.0	255.0	1.41	0.33	0.12	0.10	0.03	0.40	0.15	59.10	2.19	0.06	0.02	0.23	0.09	0.30	0.11	100.00	100.00	100.00
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0081	0.0029	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.43	42.86	71.41

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 36 INFLUENT AND EFFLUENT LEVELS OF PENTACHLOROPHENOL AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Dec.20-21	207382.0	201.0	0.13	0.03	0.0075	0.0	0.0	0.03	0.0075	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.00	9999.0	100.00
Jan.5-6	270130.0	165.0	0.18	0.03	0.0080	0.0	0.0	0.03	0.0080	14.00	0.09	0.0013	0.0003	0.0	0.0	0.0013	0.0003	95.76	9999.0	95.76
Jan.11-12	303726.0	240.0	0.10	0.02	0.0073	0.09	0.03	0.11	0.03	21.00	0.0	0.0	0.0	0.08	0.02	0.08	0.02	100.00	11.11	29.02
Jan.18-19	233810.0	211.0	0.0	0.0	0.0	0.23	0.05	0.23	0.05	22.00	0.0	0.0	0.0	0.16	0.04	0.16	0.04	9999.0	30.43	30.43
Jan.25-26	272054.0	249.0	0.23	0.06	0.02	0.09	0.02	0.15	0.04	12.00	0.0	0.0	0.0	0.08	0.02	0.08	0.02	100.00	11.11	45.48
WINTER AVERAGE	289727.7	220.2	0.11	0.02	0.0064	0.07	0.02	0.09	0.02	26.02	0.02	0.0002	0.0001	0.05	0.01	0.05	0.01	98.94	17.55	40.34
Apr.13-14	353664.0	199.0	0.0	0.0	0.0	0.34	0.12	0.34	0.12	9.00	0.10	0.0009	0.0003	0.19	0.07	0.19	0.07	8888.0	44.12	8888.0
Apr.21-22	286474.0	211.0	0.08	0.02	0.0045	0.0	0.0	0.02	0.0045	6.00	0.35	0.0021	0.0006	0.0	0.0	0.0021	0.0006	86.73	9999.0	86.73
Apr.26-27	290186.0	249.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
May.2-3	358206.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
SPRING AVERAGE	322360.0	209.0	0.02	0.0040	0.0011	0.08	0.03	0.09	0.03	10.55	0.11	0.0008	0.0002	0.05	0.02	0.05	0.02	86.73	44.12	86.73
Jun.22-23	284284.0	250.0	0.0	0.0	0.0	0.85	0.24	0.85	0.24	11.00	0.0	0.0	0.0	0.29	0.08	0.29	0.08	9999.0	65.88	65.88
Jul.11-12	268768.0	96.00	0.48	0.05	0.01	0.25	0.07	0.30	0.08	10.30	0.11	0.0011	0.0003	0.20	0.05	0.20	0.05	97.56	28.00	32.05
Aug.2-3	276032.0	137.0	0.10	0.01	0.0038	1.00	0.28	1.01	0.28	5.70	0.21	0.0012	0.0003	0.20	0.06	0.20	0.06	91.26	80.00	80.15
Aug.8-9	314622.0	182.0	0.05	0.0096	0.0030	0.13	0.04	0.14	0.04	12.60	0.08	0.0010	0.0003	0.18	0.06	0.18	0.06	89.55	8888.0	8888.0
SUMMER AVERAGE	285996.5	166.5	0.16	0.02	0.0048	0.56	0.16	0.57	0.16	9.90	0.10	0.0008	0.0002	0.22	0.06	0.22	0.06	92.78	55.29	59.36
OVERALL AVERAGE	297888.9	201.8	0.10	0.02	0.0044	0.21	0.06	0.23	0.07	16.99	0.07	0.0005	0.0002	0.10	0.03	0.10	0.03	95.10	37.52	62.94
MAXIMUM	370464.0	255.0	0.48	0.06	0.02	1.00	0.28	1.01	0.28	59.10	0.35	0.0021	0.0006	0.29	0.08	0.29	0.08	100.00	80.00	100.00
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	86.73	11.11	29.02

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 17 INFLUENT AND EFFLUENT LEVELS OF IRON AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Rem		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370444.0	255.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Dec.20-21	207382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	27000.0	4455.0	1203.4	1200.0	324.2	5655.0	1527.6	14.00	18000.0	252.0	68.07	120.0	32.42	372.0	100.5	94.34	90.00	93.42
Jan.11-12	303726.0	240.0	30000.0	7200.0	2186.8	1700.0	516.3	8900.0	2703.2	21.00	21000.0	441.0	133.9	180.0	54.67	621.0	188.6	93.88	89.41	93.02
Jan.18-19	233810.0	211.0	42000.0	8862.0	2072.0	2500.0	584.5	11362.0	2656.5	22.00	30000.0	660.0	154.3	170.0	39.75	830.0	194.1	92.55	93.20	92.69
Jan.25-26	272856.0	249.0	59000.0	14691.0	4008.5	1500.0	409.3	16191.0	4417.8	12.00	31000.0	372.0	101.5	110.0	30.01	482.0	131.5	97.47	92.67	97.02
WINTER AVERAGE	289727.7	220.2	26333.3	5868.0	1578.5	1150.0	305.7	7018.0	1884.2	26.02	16666.7	287.5	76.31	96.67	26.14	384.2	102.4	94.56	91.32	94.04
Apr.13-14	353666.0	199.0	43240.0	8604.8	3043.2	0.0	0.0	8604.8	3043.2	9.00	25380.0	228.4	80.78	100.00	35.37	328.4	116.2	97.35	8888.0	8888.0
Apr.21-22	284476.0	211.0	36660.0	7735.3	2216.0	2500.0	716.2	10235.3	2932.1	6.00	25050.0	155.1	44.43	750.0	214.9	905.1	259.3	97.99	70.00	91.16
Apr.26-27	290106.0	249.0	34780.0	8660.2	2512.4	2300.0	667.2	10960.2	3179.6	7.00	27260.0	199.8	55.34	80.00	23.21	279.8	78.57	97.00	96.52	97.53
Aug.2-3	358206.0	180.0	51700.0	9306.0	3333.5	1100.0	394.0	10406.0	3727.5	20.20	28200.0	569.6	204.0	0.0	0.0	569.6	204.0	93.00	100.00	94.53
SPRING AVERAGE	322254.6	209.8	41595.0	8576.6	2776.3	1475.0	444.4	10051.6	3220.6	10.55	26672.5	286.0	96.16	232.5	48.36	518.5	144.5	96.75	88.84	94.40
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jul.11-12	248740.0	96.00	2538.0	245.7	66.03	1600.0	430.0	1845.7	496.1	10.30	1880.0	19.36	5.20	1700.0	456.9	1719.4	462.1	92.12	8888.0	8888.0
Aug.2-3	276032.0	137.0	32430.0	4442.9	1226.4	2100.0	579.7	6542.9	1806.1	5.70	31020.0	176.8	48.81	100.00	27.60	276.8	76.41	96.02	95.24	95.77
Aug.8-9	314622.0	182.0	28200.0	5132.4	1614.8	1200.0	377.5	6332.4	1992.3	12.60	25850.0	325.7	102.5	140.0	44.05	465.7	146.5	93.65	88.33	92.65
SUMMER AVERAGE	285906.5	166.5	15792.0	2455.2	726.8	1225.0	346.8	3680.2	1073.6	9.90	14687.5	130.5	39.12	485.0	132.1	615.5	171.3	93.93	91.79	94.21
OVERALL AVERAGE	297888.9	201.8	27682.0	5666.8	1677.4	1264.3	357.1	6931.1	2034.4	16.99	18960.0	242.2	71.35	246.4	68.49	488.6	139.8	95.19	90.60	94.20
MAXIMUM	370444.0	255.0	59000.0	14691.0	4008.5	2500.0	716.2	16191.0	4417.8	59.10	31020.0	660.0	204.0	1700.0	456.9	1719.4	462.1	97.99	100.00	97.53
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.12	70.00	91.16

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 38 INFLUENT AND EFFLUENT LEVELS OF ALUMINUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370444.0	255.0	8000.0	2040.0	755.7	430.0	159.3	2470.0	915.0	20.00	8100.0	226.0	84.02	220.0	81.50	446.8	165.5	88.88	48.84	81.91
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	9100.0	1501.5	405.6	2000.0	756.4	4301.5	1162.0	14.00	5800.0	81.20	21.93	130.0	35.12	211.2	57.05	94.59	95.36	95.09
Jan.11-12	303726.0	240.0	9400.0	2256.0	685.2	510.0	154.9	2766.0	840.1	21.00	6300.0	132.3	40.18	200.0	60.75	332.3	100.9	94.14	60.78	87.99
Jan.18-19	233810.0	211.0	5400.0	1139.4	266.4	370.0	86.51	1509.4	352.9	22.00	6600.0	145.2	33.95	200.0	46.76	345.2	80.71	87.26	45.95	77.13
Jan.25-26	272854.0	249.0	8500.0	2114.5	577.5	370.0	101.0	2486.5	678.5	12.00	260.0	3.12	0.85	180.0	49.11	183.1	49.97	99.85	51.35	92.64
WINTER AVERAGE	289727.7	220.2	6733.3	1500.9	448.4	746.7	209.7	2255.6	658.1	26.02	4510.0	98.10	30.16	155.0	45.54	253.1	75.70	92.94	60.46	86.95
Apr.13-14	353666.0	199.0	8960.0	1783.0	630.6	380.0	134.4	2163.0	765.0	9.00	11060.0	99.54	35.2	180.0	63.66	279.5	98.86	94.42	52.63	87.08
Apr.21-22	286474.0	211.0	5488.0	1158.0	331.7	520.0	149.0	1678.0	480.7	6.00	6004.0	36.02	10.32	750.0	214.9	786.0	225.2	96.89	8888.0	8888.0
Apr.26-27	290106.0	249.0	7280.0	1812.7	525.9	230.0	66.72	2042.7	592.6	7.00	5451.0	38.16	11.07	210.0	60.92	248.2	71.99	97.90	8.70	87.85
May.2-3	358206.0	180.0	9520.0	1713.6	613.8	4700.0	1683.6	6413.6	2297.4	20.20	6636.0	134.0	48.02	150.0	53.73	284.0	101.7	92.18	96.81	95.57
SPRING AVERAGE	322325.0	209.8	7812.0	1616.0	525.5	1457.5	508.4	3074.3	1033.9	10.55	7287.8	76.96	26.15	322.5	98.29	399.4	124.4	95.34	52.71	90.17
Jun.22-23	284204.0	250.0	2856.0	714.0	202.9	150.0	42.63	864.0	245.6	11.00	3001.0	33.89	9.63	110.0	31.26	143.9	40.89	95.25	26.67	83.35
Jul.11-12	268768.0	96.80	560.0	54.21	14.57	380.0	102.1	434.2	116.7	10.30	403.0	4.15	1.12	810.0	217.7	814.2	218.8	92.34	8888.0	8888.0
Aug.2-3	276032.0	137.0	8960.0	1227.5	338.8	680.0	187.7	1907.5	526.5	5.70	7900.0	45.03	12.43	500.0	138.0	545.0	150.4	96.33	26.47	71.43
Aug.8-9	314622.0	182.0	8400.0	1528.8	481.0	520.0	163.6	2048.8	644.6	12.60	6557.0	82.62	25.99	380.0	119.6	462.6	145.5	94.60	26.92	77.42
SUMMER AVERAGE	285906.5	166.5	5196.0	881.1	259.3	432.5	124.0	1313.6	383.3	9.90	4485.3	41.42	12.29	450.0	126.6	491.4	138.9	94.63	26.69	77.40
OVERALL AVERAGE	297888.9	201.8	6601.7	1360.4	416.4	860.0	270.6	2220.4	687.0	16.99	5296.6	75.86	23.91	287.1	83.78	363.0	107.7	94.20	49.13	85.22
MAXIMUM	370444.0	255.0	9520.0	2256.0	755.7	4700.0	1683.6	6413.6	2297.4	59.10	11060.0	226.0	84.02	810.0	217.7	814.2	225.2	99.85	96.81	95.57
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.26	8.70	71.43

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 39 INFLUENT AND EFFLUENT LEVELS OF ARSENIC AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7.	370464.0	255.0	0.51	2.17	0.80	0.0	0.0	2.17	0.80	28.00	12.90	0.36	0.13	0.0	0.0	0.36	0.13	83.36	9999.0	83.36
Dec.20-21	207382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	18.60	3.07	0.83	0.0	0.0	3.07	0.83	14.00	16.40	0.23	0.06	0.0	0.0	0.23	0.06	92.52	9999.0	92.52
Jan.11-12	303726.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.18-19	233810.0	211.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.25-26	272054.0	249.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
WINTER AVERAGE	289727.7	220.2	4.52	0.87	0.27	0.0	0.0	0.87	0.27	26.92	4.88	0.10	0.03	0.0	0.0	0.10	0.03	87.94	9999.0	87.94
Apr.13-14	353666.0	199.0	2.12	0.42	0.15	0.0	0.0	0.42	0.15	9.00	2.75	0.02	0.0088	0.0	0.0	0.02	0.0088	94.13	9999.0	94.13
Apr.21-22	286474.0	211.0	1.31	0.28	0.08	0.0	0.0	0.28	0.08	6.00	2.24	0.01	0.0039	0.0	0.0	0.01	0.0039	95.14	9999.0	95.14
Apr.26-27	290106.0	249.0	16.20	4.03	1.17	0.0	0.0	4.03	1.17	7.00	2.06	0.01	0.0042	0.0	0.0	0.01	0.0042	99.64	9999.0	99.64
May.2-3	350206.0	180.0	32.30	5.81	2.00	0.0	0.0	5.81	2.00	20.20	25.00	0.52	0.19	0.0	0.0	0.52	0.19	91.04	9999.0	91.04
SPRING AVERAGE	322347.4	209.8	12.98	2.64	0.87	0.0	0.0	2.64	0.87	10.55	8.21	0.14	0.05	0.0	0.0	0.14	0.05	94.99	9999.0	94.99
Jun.22-23	284204.0	250.0	11.60	2.90	0.82	0.0	0.0	2.90	0.82	11.00	2.75	0.03	0.0086	0.0	0.0	0.03	0.0086	98.96	9999.0	98.96
Jul.11-12	268768.0	96.80	2.10	0.20	0.05	0.0	0.0	0.20	0.05	10.30	18.90	0.19	0.05	0.0	0.0	0.19	0.05	4.24	9999.0	4.24
Aug.2-3	276032.0	137.0	22.20	3.04	0.84	0.0	0.0	3.04	0.84	5.70	31.00	0.18	0.05	0.0	0.0	0.18	0.05	94.19	9999.0	94.19
Aug.8-9	314622.0	182.0	24.20	4.40	1.39	0.0	0.0	4.40	1.39	12.60	10.30	0.13	0.04	0.0	0.0	0.13	0.04	97.05	9999.0	97.05
SUMMER AVERAGE	285906.5	166.5	15.03	2.64	0.78	0.0	0.0	2.64	0.78	9.90	15.74	0.13	0.04	0.0	0.0	0.13	0.04	73.61	9999.0	73.61
OVERALL AVERAGE	297888.9	201.0	9.94	1.88	0.59	0.0	0.0	1.88	0.59	16.99	8.94	0.12	0.04	0.0	0.0	0.12	0.04	85.03	9999.0	85.03
MAXIMUM	370464.0	255.0	32.30	5.81	2.00	0.0	0.0	5.81	2.00	59.10	31.00	0.52	0.19	0.0	0.0	0.52	0.19	99.64	9999.0	99.64
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.24	9999.0	4.24

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 40 INFLUENT AND EFFLUENT LEVELS OF CALCIUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	28000.0	7140.0	2645.1	87000.0	32230.4	94140.0	34875.5	28.00	29000.0	812.0	300.8	72000.0	26673.4	72812.0	26974.2	88.63	17.24	22.66
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	29000.0	4785.0	1292.6	63000.0	17018.2	67785.0	18310.8	14.00	20000.0	280.0	75.64	65000.0	17558.4	65280.0	17634.1	94.15	8888.0	8888.0
Jan.11-12	303726.0	240.0	33000.0	7920.0	2405.5	88000.0	24298.1	87920.0	26703.6	21.00	23000.0	483.0	146.7	74000.0	22475.7	74483.0	22622.4	93.90	7.50	15.28
Jan.18-19	233810.0	211.0	25000.0	5275.0	1233.3	75000.0	17535.7	80275.0	18769.1	22.00	24000.0	528.0	123.5	71000.0	16600.5	71528.0	16724.0	89.99	5.33	10.90
Jan.25-26	272854.0	249.0	29000.0	7221.0	1970.3	79000.0	21555.5	86221.0	23525.7	12.00	24000.0	288.0	78.58	75000.0	20464.0	75288.0	20542.6	96.01	5.06	12.68
WINTER AVERAGE	289727.7	220.2	24000.0	5390.2	1591.1	66000.0	18773.0	69390.2	20364.1	26.02	20000.0	398.5	120.9	59500.0	17295.4	59898.5	17416.2	92.54	8.78	15.38
Apr.13-14	353666.0	199.0	31350.0	6238.7	2206.4	82000.0	29000.6	88238.6	31207.0	9.00	27380.0	246.4	87.15	73000.0	25817.6	73246.4	25904.8	96.05	10.98	16.99
Apr.21-22	286474.0	211.0	17600.0	3713.6	1063.8	91000.0	26069.1	94713.6	27133.0	6.00	22940.0	137.6	39.43	79000.0	22631.4	79137.6	22670.9	96.29	13.19	16.45
Apr.26-27	290106.0	249.0	28050.0	6984.4	2026.2	74000.0	21467.8	80984.4	23494.1	7.00	21460.0	150.2	43.58	72000.0	20887.6	72150.2	20931.2	97.85	2.70	10.91
May.2-3	350206.0	180.0	38500.0	6930.0	2482.4	76000.0	27223.7	82930.0	29706.0	20.20	25160.0	508.2	182.1	50000.0	17910.3	50508.2	18092.4	92.67	34.21	39.10
SPRING AVERAGE	322325.6	209.0	28875.0	5966.7	1944.7	80750.0	25940.3	86716.7	27885.0	10.55	24235.0	260.6	88.05	68500.0	21811.7	68760.6	21899.8	95.71	15.27	20.86
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jul.11-12	248768.0	96.80	2090.0	202.3	54.37	68000.0	18276.2	68202.3	18330.6	10.30	1554.0	16.01	4.36	76000.0	20426.4	76016.0	20430.7	92.09	8888.0	8888.0
Aug.2-3	276032.0	137.0	29150.0	3993.5	1102.3	87000.0	24014.8	90993.5	25117.1	5.70	25900.0	147.6	40.75	91000.0	25118.9	91147.6	25159.7	96.30	8888.0	8888.0
Aug.8-9	314622.0	182.0	28600.0	5205.2	1637.7	71000.0	22338.2	76205.2	23975.8	12.60	20720.0	261.1	82.14	61000.0	19191.9	61261.1	19274.1	94.98	14.48	19.61
SUMMER AVERAGE	285906.5	166.5	14960.0	2350.3	698.6	56500.0	16157.3	58850.3	16855.9	9.90	12043.5	106.2	31.80	57000.0	16184.3	57106.2	16216.1	94.46	14.48	19.61
OVERALL AVERAGE	297888.9	201.8	22810.0	4686.3	1437.1	66642.9	20873.4	71329.2	21510.6	16.99	18936.7	275.6	86.04	61357.1	18268.3	61632.7	18354.4	94.08	12.26	18.29
MAXIMUM	370464.0	255.0	38500.0	7920.0	2645.1	91000.0	32230.4	94713.6	34875.5	59.10	29000.0	812.0	300.8	91000.0	26673.4	91147.6	26974.2	97.85	34.21	39.10
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.63	2.70	10.90

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 41 INFLUENT AND EFFLUENT LEVELS OF CADMIUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370466.0	255.0	6.40	1.63	0.60	0.0	0.0	1.63	0.60	20.00	13.00	0.36	0.13	0.0	0.0	0.36	0.13	77.78	9999.0	77.78
Dec.20-21	287302.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	6.30	1.84	0.28	0.0	0.0	1.84	0.28	14.00	4.88	0.07	0.02	0.0	0.0	0.07	0.02	93.54	9999.0	93.54
Jan.11-12	303726.0	240.0	3.70	0.89	0.27	0.0	0.0	0.89	0.27	21.00	5.10	0.11	0.03	0.0	0.0	0.11	0.03	87.94	9999.0	87.94
Jan.18-19	233810.0	211.0	6.40	1.35	0.32	0.0	0.0	1.35	0.32	22.00	6.40	0.14	0.03	0.0	0.0	0.14	0.03	89.57	9999.0	89.57
Jan.25-26	272854.0	249.0	6.40	1.15	0.31	0.0	0.0	1.15	0.31	12.00	5.60	0.07	0.02	0.0	0.0	0.07	0.02	94.13	9999.0	94.13
WINTER AVERAGE	289727.7	220.2	4.57	1.01	0.30	0.0	0.0	1.01	0.30	26.02	5.82	0.12	0.04	0.0	0.0	0.12	0.04	88.58	9999.0	88.58
Apr.13-14	353666.0	199.0	4.84	0.96	0.34	0.0	0.0	0.96	0.34	9.00	6.60	0.06	0.02	0.0	0.0	0.06	0.02	93.83	9999.0	93.83
Apr.21-22	286474.0	211.0	4.84	1.02	0.29	0.0	0.0	1.02	0.29	6.00	4.62	0.03	0.0079	0.0	0.0	0.03	0.0079	97.29	9999.0	97.29
Apr.26-27	290106.0	249.0	7.48	1.86	0.54	0.0	0.0	1.86	0.54	7.00	4.62	0.03	0.0094	0.0	0.0	0.03	0.0094	98.26	9999.0	98.26
Nov.2-3	350206.0	180.0	5.72	1.03	0.37	0.0	0.0	1.03	0.37	20.20	4.62	0.09	0.03	0.0	0.0	0.09	0.03	90.94	9999.0	90.94
SPRING AVERAGE	322154.1	209.8	5.72	1.22	0.39	0.0	0.0	1.22	0.39	10.55	5.12	0.05	0.02	0.0	0.0	0.05	0.02	95.08	9999.0	95.08
Jun.22-23	284204.0	250.0	3.56	0.89	0.25	0.0	0.0	0.89	0.25	11.00	5.48	0.06	0.02	0.0	0.0	0.06	0.02	93.23	9999.0	93.23
Jul.11-12	260748.0	96.80	0.00	0.09	0.02	0.0	0.0	0.09	0.02	10.30	0.66	0.0068	0.0018	0.0	0.0	0.0068	0.0018	92.02	9999.0	92.02
Aug.2-3	276032.0	137.0	6.20	0.85	0.23	0.0	0.0	0.85	0.23	5.70	6.60	0.04	0.01	0.0	0.0	0.04	0.01	95.57	9999.0	95.57
Aug.8-9	314622.0	182.0	6.20	1.13	0.36	0.0	0.0	1.13	0.36	12.60	5.94	0.07	0.02	0.0	0.0	0.07	0.02	93.37	9999.0	93.37
SUMMER AVERAGE	285966.5	166.5	4.21	0.74	0.22	0.0	0.0	0.74	0.22	9.90	4.67	0.04	0.01	0.0	0.0	0.04	0.01	93.55	9999.0	93.55
OVERALL AVERAGE	297888.9	201.8	4.79	0.99	0.30	0.0	0.0	0.99	0.30	16.99	5.29	0.08	0.03	0.0	0.0	0.08	0.03	92.11	9999.0	92.11
MAXIMUM	370466.0	255.0	7.48	1.86	0.60	0.0	0.0	1.86	0.60	59.10	13.00	0.36	0.13	0.0	0.0	0.36	0.13	98.26	9999.0	98.26
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.78	9999.0	77.78

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 42 INFLUENT AND EFFLUENT LEVELS OF CHROMIUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	770.0	196.3	72.74	100.00	37	296.3	109.8	28.00	1200.0	33.60	12.45	10.00	3.70	43.60	16.15	82.89	90.00	85.29
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	660.0	108.9	29.42	20.00	5.40	128.9	34.82	14.00	610.0	8.54	2.31	0.0	0.0	8.54	2.31	92.16	100.00	93.37
Jan.11-12	363726.0	240.0	720.0	172.8	52.48	60.00	18.22	232.8	70.71	21.00	580.0	12.18	3.70	10.00	3.04	22.18	6.74	92.95	83.33	90.47
Jan.18-19	233810.0	211.0	630.0	132.9	31.08	40.00	9.35	172.9	40.43	22.00	790.0	17.38	4.06	0.0	0.0	17.38	4.06	86.93	100.00	89.95
Jan.25-26	272854.0	249.0	1000.0	249.0	67.94	60.00	16.37	309.0	84.31	12.00	910.0	10.92	2.98	0.0	0.0	10.92	2.98	95.61	100.00	96.47
WINTER AVERAGE	289727.7	220.2	630.0	143.3	42.28	46.67	14.40	190.0	56.68	26.02	481.7	13.77	4.25	3.33	1.12	17.10	5.37	90.11	94.67	91.11
Apr.13-14	353666.0	199.0	592.0	117.8	41.66	20.00	7.07	137.8	48.74	9.00	816.0	7.34	2.60	0.0	0.0	7.34	2.60	93.77	100.00	94.67
Apr.21-22	286474.0	211.0	407.0	85.88	24.60	0.0	0.0	85.88	24.60	6.00	528.0	3.17	0.91	0.0	0.0	3.17	0.91	96.31	9999.0	96.31
Apr.26-27	299106.0	249.0	481.0	119.8	36.75	30.00	8.70	149.8	43.45	7.00	528.0	3.70	1.07	0.0	0.0	3.70	1.07	96.91	100.00	97.53
May.2-3	358206.0	180.0	999.0	179.8	64.41	60.00	21.49	239.8	85.90	20.20	576.0	11.64	4.17	0.0	0.0	11.64	4.17	93.53	100.00	95.15
SPRING AVERAGE	322412.4	209.8	619.8	125.8	41.36	27.50	9.32	153.3	50.67	10.55	612.0	6.46	2.19	0.0	0.0	6.46	2.19	95.13	100.00	95.92
Jun.22-23	284294.0	250.0	244.0	61.00	17.34	10.00	2.84	71.00	20.18	11.00	422.0	4.64	1.32	0.0	0.0	4.64	1.32	92.39	100.00	93.46
Jul.11-12	268768.0	96.80	111.0	10.74	2.89	130.0	34.94	140.7	37.83	10.30	57.60	0.59	0.16	30.00	8.06	30.59	8.22	94.48	76.92	78.26
Aug.2-3	276032.0	137.0	2553.0	349.8	96.55	210.0	57.97	559.8	154.5	5.70	1248.0	7.11	1.96	60.00	16.56	67.11	18.53	97.97	71.43	88.01
Aug.8-9	314622.0	182.0	1332.0	242.4	76.27	120.0	37.75	362.4	114.0	12.60	1152.0	14.52	4.57	10.00	3.15	24.52	7.71	94.81	91.67	93.24
SUMMER AVERAGE	285906.5	166.5	1060.0	166.0	48.26	117.5	33.38	283.5	81.64	9.96	719.9	6.72	2.00	25.00	6.94	31.72	8.95	94.71	85.00	88.24
OVERALL AVERAGE	297888.9	201.0	749.9	144.8	43.72	61.43	18.37	206.2	62.09	16.99	672.7	9.67	3.02	8.57	2.47	18.24	5.48	93.67	92.78	91.71
MAXIMUM	370464.0	255.0	2553.0	349.8	96.55	210.0	57.97	559.8	154.5	59.10	1248.0	33.60	12.45	60.00	16.56	67.11	18.53	97.97	100.00	97.53
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.89	71.43	78.26

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 43 INFLUENT AND EFFLUENT LEVELS OF COPPER AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	660.0	163.2	60.46	10.00	3.70	173.2	64.16	28.00	650.0	18.20	6.74	10.00	3.70	28.20	10.45	88.85	0.0	83.72
Dec.20-21	207382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	720.0	118.8	32.09	20.00	5.40	138.8	37.49	14.00	490.0	6.86	1.85	0.0	0.0	6.86	1.85	94.23	100.00	95.06
Jan.11-12	303726.0	240.0	580.0	139.2	42.28	40.00	12.15	179.2	54.43	21.00	470.0	9.87	3.00	30.00	9.11	39.87	12.11	92.91	25.00	77.75
Jan.18-19	233810.0	211.0	590.0	124.5	29.11	60.00	14.03	184.5	43.14	22.00	510.0	11.22	2.62	10.00	2.34	21.22	4.96	90.99	83.33	88.50
Jan.25-26	272854.0	249.0	620.0	154.4	42.12	20.00	5.46	174.4	47.58	12.00	480.0	5.76	1.57	0.0	0.0	5.76	1.57	96.27	100.00	96.70
WINTER AVERAGE	289727.7	220.2	525.0	116.7	34.34	25.00	6.79	141.7	41.13	26.02	433.3	8.65	2.63	8.33	2.53	16.99	5.16	92.65	61.67	88.34
Apr.13-14	353666.0	199.0	706.0	140.5	49.69	0.0	0.0	140.5	49.69	9.00	688.0	6.19	2.19	10.00	3.54	16.19	5.73	95.59	8888.0	8888.0
Apr.21-22	286474.0	211.0	454.0	95.79	27.44	0.0	0.0	95.79	27.44	6.00	448.0	2.69	0.77	40.00	11.46	42.69	12.23	97.19	8888.0	8888.0
Apr.26-27	290106.0	249.0	655.0	163.1	47.31	80.00	23.21	243.1	70.52	7.00	512.0	3.58	1.04	10.00	2.90	13.58	3.94	97.80	87.50	94.41
Aug.2-3	358206.0	180.0	655.0	117.9	42.23	40.00	14.33	157.9	56.56	20.20	520.0	10.50	3.76	0.0	0.0	10.50	3.76	91.09	100.00	93.35
SPRING AVERAGE	322411.1	209.8	617.5	129.3	41.67	30.00	9.38	159.3	51.05	10.55	542.0	5.74	1.94	15.00	4.47	20.74	6.41	95.42	93.75	93.88
Jun.22-23	284204.0	250.0	217.0	54.25	15.42	10.00	2.84	64.25	18.26	11.00	296.0	3.26	0.93	0.0	0.0	3.26	0.93	94.00	100.00	94.93
Jul.11-12	268768.0	96.00	50.40	4.88	1.31	20.00	5.38	24.88	6.69	10.30	39.20	0.40	0.11	30.00	8.06	30.40	8.17	91.72	8888.0	8888.0
Aug.2-3	276032.0	137.0	554.0	75.90	20.95	20.00	5.52	95.90	26.47	5.70	456.0	2.60	0.72	10.00	2.76	12.60	3.48	96.58	50.00	86.86
Aug.8-9	314622.0	182.0	756.0	137.6	43.29	30.00	9.44	167.6	52.73	12.60	496.0	6.25	1.97	20.00	6.29	26.25	8.26	95.46	33.33	84.34
SUMMER AVERAGE	285906.5	166.5	394.4	68.15	20.24	20.00	5.79	88.15	26.04	9.90	321.8	3.13	0.93	15.00	4.28	18.13	5.21	94.44	61.11	88.71
OVERALL AVERAGE	297888.9	201.8	514.1	106.4	32.41	25.00	7.25	131.4	39.65	16.99	432.5	6.24	1.95	12.14	3.58	18.38	5.53	94.65	67.92	89.56
MAXIMUM	370464.0	255.0	756.0	163.2	60.46	80.00	23.21	243.1	70.52	59.10	688.0	18.20	6.74	40.00	11.46	42.69	12.23	97.80	100.00	96.70
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.85	0.0	77.75

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 44 INFLUENT AND EFFLUENT LEVELS OF MERCURY AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	1.40	0.36	0.13	0.05	0.02	0.41	0.15	28.00	0.64	0.02	0.0066	0.0	0.0	0.02	0.0066	94.98	100.00	95.60
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	2.80	0.46	0.12	0.17	0.05	0.63	0.17	14.00	1.40	0.02	0.0053	0.03	0.0001	0.05	0.01	95.76	82.35	92.15
Jan.11-12	303726.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.18-19	233810.0	211.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.25-26	272054.0	249.0	1.40	0.35	0.10	0.06	0.02	0.41	0.11	12.00	1.10	0.01	0.0036	0.0	0.0	0.01	0.0036	96.21	100.00	96.77
WINTER AVERAGE	289727.7	220.2	0.93	0.19	0.06	0.05	0.01	0.24	0.07	26.02	0.52	0.0085	0.0026	0.0050	0.0014	0.01	0.0039	95.65	94.12	94.84
Apr.13-14	353666.0	199.0	1.39	0.28	0.10	0.04	0.01	0.32	0.11	9.00	1.32	0.01	0.0042	0.01	0.0035	0.02	0.0077	95.71	75.00	93.09
Apr.21-22	286474.0	211.0	1.07	0.23	0.06	0.04	0.01	0.27	0.08	6.00	1.15	0.0069	0.0020	0.02	0.0057	0.03	0.0077	96.94	50.00	89.88
Apr.26-27	290106.0	249.0	1.70	0.42	0.12	0.07	0.02	0.49	0.14	7.00	0.99	0.0069	0.0020	0.04	0.01	0.05	0.01	98.36	42.86	90.49
Nov.2-3	358206.0	100.0	1.70	0.31	0.11	0.03	0.01	0.34	0.12	20.20	1.48	0.03	0.01	0.02	0.0072	0.05	0.02	90.23	33.33	85.15
SPRING AVERAGE	322336.9	209.8	1.46	0.31	0.10	0.05	0.01	0.35	0.11	10.55	1.23	0.01	0.0047	0.02	0.0070	0.04	0.01	95.31	50.30	89.65
Jun.22-23	284204.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jul.11-12	268768.0	96.80	2.03	0.20	0.05	0.09	0.02	0.29	0.08	10.30	1.32	0.01	0.0037	0.08	0.02	0.09	0.03	93.08	11.11	67.33
Aug.2-3	276032.0	137.0	2.11	0.29	0.08	0.10	0.03	0.39	0.11	5.70	2.47	0.01	0.0039	0.10	0.03	0.11	0.03	95.13	0.0	70.68
Aug.8-9	314622.0	182.0	0.0	0.0	0.0	0.10	0.03	0.10	0.03	12.60	0.0	0.0	0.0	0.05	0.02	0.05	0.02	9999.0	50.00	50.00
SUMMER AVERAGE	285796.5	166.5	1.03	0.12	0.03	0.07	0.02	0.19	0.05	9.90	0.95	0.0069	0.0019	0.06	0.02	0.06	0.02	94.11	20.37	62.47
OVERALL AVERAGE	297888.9	201.8	1.11	0.21	0.06	0.05	0.02	0.26	0.08	16.99	0.85	0.0096	0.0030	0.02	0.0072	0.03	0.01	95.16	54.47	83.11
MAXIMUM	370464.0	255.0	2.80	0.46	0.13	0.17	0.05	0.63	0.17	59.10	2.47	0.03	0.01	0.10	0.03	0.11	0.03	98.36	100.00	96.77
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.23	0.0	50.00

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 45 INFLUENT AND EFFLUENT LEVELS OF MAGNESIUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370446.0	255.0	5200.0	1326.0	491.2	24000.0	8891.1	25326.0	9382.4	20.00	6800.0	190.4	70.54	20000.0	7409.3	20190.4	7479.8	85.64	16.67	20.28
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	4800.0	792.0	213.9	17000.0	4592.2	17792.0	4806.2	14.00	4600.0	64.40	17.40	18000.0	4862.3	18064.4	4879.7	91.87	8888.0	8888.0
Jan.11-12	303726.0	240.0	5200.0	1248.0	379.1	20000.0	6074.5	21248.0	6453.6	21.00	5300.0	111.3	33.80	19000.0	5770.8	19111.3	5804.6	91.00	5.00	10.06
Jan.18-19	233810.0	211.0	3700.0	780.7	182.5	18000.0	4208.6	18780.7	4391.1	22.00	5100.0	112.2	26.23	160000.0	37409.6	160112.2	37435.8	85.63	8888.0	8888.0
Jan.25-26	272854.0	249.0	5800.0	1444.2	396.1	160000.0	43656.6	161444.2	44050.7	12.00	4800.0	57.60	15.72	160000.0	43656.6	160057.6	43672.4	96.01	0.0	0.86
WINTER																				
AVERAGE	289727.7	220.2	4116.7	931.8	276.8	39833.3	11237.2	40765.1	11514.0	26.02	4433.3	89.32	27.28	62833.3	16518.1	62922.6	16545.4	90.05	7.22	10.40
Apr.13-14	353666.0	199.0	5720.0	1138.3	402.6	23000.0	8134.3	24138.3	8536.9	9.00	4290.0	56.61	20.02	21000.0	7427.0	21056.6	7447.0	95.03	8.70	12.77
Apr.21-22	286474.0	211.0	2652.0	559.6	160.3	41000.0	11745.4	41559.6	11905.7	6.00	4440.0	26.64	7.63	20000.0	5729.5	20026.6	5737.1	95.24	51.22	51.81
Apr.26-27	290106.0	249.0	4160.0	1035.8	300.5	18000.0	5221.9	19035.8	5522.4	7.00	3922.0	27.45	7.96	18000.0	5221.9	18027.5	5229.9	97.35	0.0	5.30
May.2-3	358206.0	180.0	8840.0	1591.2	570.0	22000.0	7880.5	23591.2	8450.5	20.20	5624.0	113.6	40.69	13000.0	4656.7	13113.6	4697.4	92.86	40.91	44.41
SPRING																				
AVERAGE	322320.8	209.8	5343.0	1681.2	358.3	26000.0	8245.5	27681.2	8603.9	10.55	5069.0	56.08	19.08	18000.0	5758.8	18056.1	5777.8	95.12	25.21	28.57
Jun.22-23	284294.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jul.11-12	260768.0	96.80	296.0	28.65	7.70	17000.0	4569.1	17028.7	4576.8	10.30	333.0	3.43	0.92	16000.0	4300.3	16003.4	4301.2	88.03	5.88	6.02
Aug.2-3	276032.0	137.0	4420.0	605.5	167.1	19000.0	5244.6	19605.5	5411.8	5.70	7030.0	40.07	11.06	21000.0	5796.7	21040.1	5807.7	93.38	8888.0	8888.0
Aug.8-9	314622.0	182.0	3952.0	719.3	226.3	16000.0	5034.0	16719.3	5260.2	12.60	4810.0	60.61	19.07	15000.0	4719.3	15060.6	4739.4	91.57	6.25	9.92
SUMMER																				
AVERAGE	285906.5	166.5	2167.0	338.4	100.3	13000.0	3711.9	13339.4	3812.2	9.90	3043.3	26.03	7.76	13000.0	3704.1	13026.0	3711.8	91.00	6.07	7.97
OVERALL																				
AVERAGE	297888.9	201.0	3910.0	804.9	249.7	28214.3	8232.3	29019.2	8482.0	16.99	4217.8	61.74	19.36	35785.7	9782.9	35847.4	9802.2	91.97	14.96	17.94
MAXIMUM	370446.0	255.0	8840.0	1591.2	570.0	160000.0	43656.6	161444.2	44050.7	59.10	7030.0	190.4	70.54	160000.0	43656.6	160112.2	43672.4	97.35	51.22	51.81
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.63	0.0	0.86

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 46 INFLUENT AND EFFLUENT LEVELS OF NICKEL AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Reaval		
		mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	160.0	40.80	15.11	50.00	18.52	90.80	33.64	28.00	170.0	4.76	1.76	40.00	14.82	44.76	16.58	80.33	20.00	50.70
Dec.20-21	207382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	230.0	37.95	10.25	50.00	13.51	87.95	23.76	14.00	140.0	1.96	0.53	30.00	8.10	31.96	8.63	94.84	40.00	63.66
Jan.11-12	303726.0	240.0	330.0	79.20	24.06	50.00	15.19	129.2	39.24	21.00	150.0	3.15	0.96	30.00	9.11	33.15	10.07	96.02	40.00	74.34
Jan.18-19	233810.0	211.0	250.0	52.75	12.33	70.00	16.37	122.7	28.70	22.00	210.0	4.62	1.08	60.00	14.03	64.62	15.11	91.24	14.29	47.36
Jan.25-26	272854.0	249.0	360.0	89.64	24.46	60.00	16.37	149.6	40.83	12.00	210.0	2.52	0.69	50.00	13.64	52.52	14.33	97.19	16.67	64.90
WINTER AVERAGE	289727.7	220.2	221.7	50.06	14.37	46.67	13.33	96.72	27.69	26.02	146.7	2.84	0.84	35.00	9.95	37.83	10.79	93.52	26.19	60.19
Apr.13-14	353666.0	199.0	139.0	27.66	9.78	50.00	17.68	77.66	27.47	9.00	221.0	1.99	0.70	40.00	14.15	41.99	14.85	92.81	20.00	45.93
Apr.21-22	286474.0	211.0	267.0	56.34	16.14	0.0	0.0	56.34	16.14	6.00	162.0	0.97	0.28	0.0	0.0	0.97	0.28	98.27	9999.0	98.27
Apr.26-27	290106.0	249.0	228.0	56.77	16.47	50.00	14.51	106.8	30.98	7.00	162.0	1.13	0.33	40.00	11.60	41.13	11.93	98.00	20.00	61.47
May.2-3	358206.0	180.0	297.0	53.46	19.15	50.00	17.91	103.5	37.06	20.20	176.0	3.56	1.27	20.00	7.16	23.56	8.44	93.35	60.00	77.23
SPRING AVERAGE	322153.4	209.8	232.8	48.56	15.39	37.50	12.52	86.06	27.91	10.55	180.3	1.91	0.65	25.00	8.23	26.91	8.87	95.61	33.33	70.73
Jun.22-23	284284.0	250.0	317.0	79.25	22.52	40.00	11.37	119.3	33.89	11.00	147.0	1.62	0.46	40.00	11.37	41.62	11.83	97.96	0.0	65.10
Jul.11-12	268768.0	96.00	50.00	4.84	1.30	70.00	18.81	74.84	20.11	10.30	19.00	0.20	0.05	60.00	16.13	60.20	16.18	95.96	14.29	19.57
Aug.2-3	276032.0	137.0	240.0	33.98	9.38	50.00	13.80	83.98	23.18	5.70	221.0	1.26	0.35	60.00	16.56	61.26	16.91	96.29	8888.0	8888.0
Aug.8-9	314622.0	182.0	240.0	45.14	14.20	30.00	9.44	75.14	23.64	12.60	162.0	2.04	0.64	20.00	6.29	22.04	6.93	95.48	33.33	70.66
SUMMER AVERAGE	285906.5	166.5	215.8	40.80	11.85	47.50	13.36	88.30	25.21	9.90	137.3	1.28	0.38	45.00	12.59	46.28	12.96	96.42	15.87	51.78
OVERALL AVERAGE	297888.9	201.8	223.1	46.98	13.94	44.29	13.11	91.27	27.05	16.99	153.6	2.13	0.65	35.00	10.21	37.13	10.86	95.06	25.32	61.60
MAXIMUM	370464.0	255.0	360.0	89.64	24.46	70.00	18.81	149.6	40.83	59.10	221.0	4.76	1.76	60.00	16.56	64.62	16.91	98.27	60.00	98.27
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.33	0.0	19.57

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 47 INFLUENT AND EFFLUENT LEVELS OF LEAD AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	580.0	147.9	54.79	0.0	0.0	147.9	54.79	28.00	590.0	16.52	6.12	0.0	0.0	16.52	6.12	88.83	9999.0	88.83
Dec.20-21	287382.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	420.0	69.30	18.72	0.0	0.0	69.30	18.72	14.00	260.0	3.64	0.98	0.0	0.0	3.64	0.98	94.75	9999.0	94.75
Jan.11-12	303726.0	240.0	520.0	124.8	37.91	0.0	0.0	124.8	37.91	21.00	310.0	6.51	1.98	0.0	0.0	6.51	1.98	94.78	9999.0	94.78
Jan.18-19	233810.0	211.0	440.0	92.84	21.71	0.0	0.0	92.84	21.71	22.00	200.0	4.40	1.03	10.00	2.34	14.40	3.37	95.26	8888.0	8888.0
Jan.25-26	272854.0	249.0	450.0	112.1	30.57	30.00	8.19	142.0	38.76	12.00	290.0	3.48	0.95	0.0	0.0	3.48	0.95	96.89	100.00	97.55
WINTER AVERAGE	289727.7	220.2	401.7	91.15	27.28	5.00	1.36	96.15	28.65	26.02	275.0	5.76	1.84	1.67	0.39	7.42	2.23	94.10	100.00	93.98
Apr.13-14	353666.0	199.0	442.0	87.96	31.11	40.00	14.15	128.0	45.25	9.00	429.0	3.86	1.37	10.00	3.54	13.86	4.90	95.61	75.00	89.17
Apr.21-22	286474.0	211.0	344.0	72.58	20.79	0.0	0.0	72.58	20.79	6.00	264.0	1.58	0.45	10.00	2.86	11.58	3.32	97.02	8888.0	8888.0
Apr.26-27	290106.0	249.0	442.0	110.1	31.93	0.0	0.0	110.1	31.93	7.00	274.0	1.92	0.56	0.0	0.0	1.92	0.56	98.26	9999.0	98.26
May.2-3	358206.0	180.0	772.0	139.0	49.78	0.0	0.0	139.0	49.78	20.20	337.0	6.81	2.44	0.0	0.0	6.81	2.44	95.10	9999.0	95.10
SPRING AVERAGE	322297.8	209.8	500.0	102.4	33.40	10.00	3.54	112.4	36.94	10.55	326.0	3.54	1.20	5.00	1.60	8.54	2.80	96.70	75.00	94.18
Jun.22-23	284204.0	250.0	323.0	80.75	22.95	10.00	2.84	90.75	25.79	11.00	164.0	1.80	0.51	0.0	0.0	1.80	0.51	97.77	100.00	98.01
Jul.11-12	268768.0	96.80	91.00	8.81	2.37	0.0	0.0	8.81	2.37	10.30	27.00	0.28	0.07	0.0	0.0	0.28	0.07	96.84	9999.0	96.84
Aug.2-3	276032.0	137.0	435.0	59.59	16.45	0.0	0.0	59.59	16.45	5.70	392.0	2.23	0.62	0.0	0.0	2.23	0.62	96.25	9999.0	96.25
Aug.8-9	314622.0	182.0	618.0	112.5	35.39	20.00	6.29	132.5	41.68	12.60	283.0	3.57	1.12	0.0	0.0	3.57	1.12	96.83	100.00	97.31
SUMMER AVERAGE	285986.5	166.5	366.8	65.41	19.29	7.50	2.28	72.91	21.57	9.90	216.5	1.97	0.58	0.0	0.0	1.97	0.58	96.92	100.00	97.10
OVERALL AVERAGE	297888.9	201.8	419.8	87.01	26.75	7.14	2.25	94.15	28.99	16.99	272.9	4.04	1.30	2.14	0.62	6.19	1.92	95.77	93.75	95.17
MAXIMUM	370464.0	255.0	772.0	147.9	54.79	40.00	14.15	147.9	54.79	59.10	590.0	16.52	6.12	10.00	3.54	16.52	6.12	98.26	100.00	98.26
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.83	75.00	89.83

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
A VALUE OF 8888 = EFFLUENT VALUE > INFLUENT VALUE
A VALUE OF 1111 = NO DATA AVAILABLE

TABLE B - 48 INFLUENT AND EFFLUENT LEVELS OF SELENIUM AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	11.45	2.92	1.08	0.0	0.0	2.92	1.08	28.00	51.60	1.44	0.54	0.0	0.0	1.44	0.54	50.52	9999.0	50.52
Dec.20-21	287302.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	9.52	1.57	0.42	0.0	0.0	1.57	0.42	14.00	7.56	0.11	0.03	0.0	0.0	0.11	0.03	93.28	9999.0	93.28
Jan.11-12	303726.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.18-19	233810.0	211.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.25-26	272854.0	249.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
WINTER AVERAGE	289727.7	220.2	3.50	0.75	0.25	0.0	0.0	0.75	0.25	26.02	9.86	0.26	0.09	0.0	0.0	0.26	0.09	71.90	9999.0	71.90
Apr.13-14	353666.0	199.0	0.48	0.10	0.03	0.0	0.0	0.10	0.03	9.00	1.05	0.0094	0.0033	0.0	0.0	0.0094	0.0033	90.11	9999.0	90.11
Apr.21-22	286474.0	211.0	1.02	0.22	0.06	0.0	0.0	0.22	0.06	6.00	0.24	0.0014	0.0004	120.0	34.38	120.0	34.38	99.33	8888.0	8888.0
Apr.26-27	290106.0	249.0	10.90	2.71	0.79	0.0	0.0	2.71	0.79	7.00	2.92	0.02	0.0059	0.0	0.0	0.02	0.0059	99.25	9999.0	99.25
May.2-3	358206.0	180.0	26.50	4.77	1.71	0.0	0.0	4.77	1.71	20.20	37.30	0.75	0.27	0.0	0.0	0.75	0.27	84.20	9999.0	84.20
SPRING AVERAGE	322374.7	209.8	9.73	1.95	0.65	0.0	0.0	1.95	0.65	10.55	10.38	0.20	0.07	30.00	8.59	30.20	8.66	93.22	9999.0	91.19
Jun.22-23	284204.0	250.0	11.30	2.83	0.80	0.0	0.0	2.83	0.80	11.00	20.40	0.22	0.06	0.0	0.0	0.22	0.06	92.06	9999.0	92.06
Jul.11-12	260768.0	96.80	1.70	0.16	0.04	0.0	0.0	0.16	0.04	10.30	34.80	0.36	0.10	0.0	0.0	0.36	0.10	8888.0	9999.0	8888.0
Aug.2-3	276032.0	137.0	17.70	2.42	0.67	0.0	0.0	2.42	0.67	5.70	38.90	0.22	0.06	0.0	0.0	0.22	0.06	90.86	9999.0	90.86
Aug.8-9	314622.0	182.0	14.30	2.60	0.82	0.0	0.0	2.60	0.82	12.60	32.40	0.41	0.13	0.0	0.0	0.41	0.13	84.31	9999.0	84.31
SUMMER AVERAGE	285906.5	166.5	11.25	2.00	0.58	0.0	0.0	2.00	0.58	9.90	31.63	0.30	0.09	0.0	0.0	0.30	0.09	89.08	9999.0	89.08
OVERALL AVERAGE	297888.9	201.0	7.49	1.45	0.46	0.0	0.0	1.45	0.46	16.99	16.22	0.25	0.09	8.57	2.46	8.82	2.54	87.10	9999.0	85.57
MAXIMUM	370464.0	255.0	26.50	4.77	1.71	0.0	0.0	4.77	1.71	59.10	51.60	1.44	0.54	120.0	34.38	120.0	34.38	99.33	9999.0	99.25
MINIMUM	233810.0	96.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.52	9999.0	50.52

NOTES:

A VALUE OF 9999 = TRACE MINUS A TRACE OR ZERO MINUS ZERO
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A VALUE OF 1111 = NO DATA AVAILABLE

TABLE 8 - 49 INFLUENT AND EFFLUENT LEVELS OF ZINC AT HAMILTON WPCP

	Flow	SS	Inf. Solid F.			Inf. Liq. F.		Total		SS	Eff. Solids F.			Eff. Liq. F.		Total		% Removal		
		ug/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	mg/l	ug/g	ug/l	Kg	ug/l	Kg	ug/l	Kg	S.Frac.	L.Frac.	Tot.
Dec.6-7	370464.0	255.0	2200.0	561.0	207.8	120.0	44.46	681.0	252.3	20.00	3100.0	86.80	32.16	30.00	11.11	116.8	43.27	84.53	75.00	82.85
Dec.20-21	287302.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1111.0	1111.0	1111.0
Jan.5-6	270130.0	165.0	1600.0	264.0	71.31	70.00	18.91	334.0	90.22	14.00	1200.0	16.80	4.54	20.00	5.40	36.80	9.94	93.44	71.43	88.98
Jan.11-12	303726.0	240.0	1700.0	408.0	123.9	160.0	48.60	568.0	172.5	21.00	1600.0	33.60	10.21	50.00	15.19	83.60	25.39	91.76	68.75	85.28
Jan.18-19	233810.0	211.0	1400.0	295.4	69.07	150.0	35.07	445.4	104.1	22.00	1600.0	35.20	8.23	50.00	11.69	85.20	19.92	88.00	66.67	80.87
Jan.25-26	272054.0	249.0	1400.0	348.6	95.12	90.00	24.56	438.6	119.7	12.00	1400.0	16.80	4.58	50.00	13.64	66.80	18.23	95.18	44.44	84.77
WINTER AVERAGE	289727.7	220.2	1363.3	312.0	94.54	98.33	28.60	411.2	123.1	26.02	1483.3	31.53	9.95	33.33	9.51	64.87	19.46	90.64	65.26	84.55
Apr.13-14	353666.0	199.0	1470.0	292.5	103.5	40.00	14.15	332.5	117.6	9.00	2030.0	18.27	6.46	70.00	24.76	88.27	31.22	93.75	8888.0	8888.0
Apr.21-22	286474.0	211.0	1274.0	268.8	77.01	40000.0	11459.0	40268.8	11536.0	6.00	1260.0	7.56	2.17	140.0	40.11	147.6	42.27	97.19	99.65	99.63
Apr.26-27	290106.0	249.0	1519.0	378.2	109.7	160.0	46.42	538.2	156.1	7.00	1330.0	9.31	2.70	50.00	14.51	59.31	17.21	97.54	68.75	88.98
Aug.2-3	350206.0	180.0	3136.0	564.5	202.2	230.0	82.39	794.5	284.6	20.20	1890.0	38.18	13.68	70.00	25.07	108.2	38.75	93.24	69.57	86.38
SPRING AVERAGE	322204.2	209.8	1849.8	376.0	123.1	10107.5	2900.5	10483.5	3023.6	10.55	1627.5	10.33	4.25	82.50	26.11	100.8	32.36	95.43	79.32	91.67
Jun.22-23	284204.0	250.0	931.0	232.8	66.15	130.0	36.95	362.8	103.1	11.00	910.0	10.01	2.84	110.0	31.26	120.0	34.11	95.70	15.38	66.92
Jul.11-12	268748.0	96.00	250.0	24.20	6.50	230.0	61.82	254.2	68.32	10.30	105.0	1.08	0.29	140.0	37.63	141.1	37.92	95.53	39.13	44.50
Aug.2-3	276032.0	137.0	1013.0	248.4	68.56	240.0	66.25	488.4	134.8	5.70	1470.0	8.38	2.31	100.00	27.60	108.4	29.92	96.63	58.33	77.81
Aug.8-9	314622.0	182.0	1519.0	276.5	86.98	180.0	56.63	456.5	143.6	12.60	1330.0	16.76	5.27	100.00	31.46	116.8	36.73	93.94	44.44	74.42
SUMMER AVERAGE	285966.5	166.5	1128.3	195.4	57.05	195.0	55.41	390.4	112.5	9.90	953.8	9.46	2.68	112.5	31.99	121.6	34.67	95.45	39.32	65.91
OVERALL AVERAGE	297888.9	201.8	1443.7	297.3	91.99	2985.7	856.8	3283.1	948.8	16.99	1373.2	21.34	6.82	70.00	20.67	91.34	27.49	93.59	60.13	80.12
MAXIMUM	370464.0	255.0	3136.0	564.5	207.8	40000.0	11459.0	40268.8	11536.0	59.10	3100.0	86.80	32.16	140.0	40.11	147.6	43.27	97.54	99.65	99.63
MINIMUM	233810.0	96.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.53	15.38	44.50

NOTES:

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A VALUE OF 1111 = NO DATA AVAILABLE

APPENDIX C

REVIEW OF THE POTENTIAL PUBLIC HEALTH CONCERNS AND ENVIRONMENTAL SIGNIFICANCE RESULTING FROM THE DISCHARGE OF SELECTED HAZARDOUS CONTAMINANTS FROM THE HAMILTON SEWAGE TREATMENT PLANT

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February 19[illegible]

HAMILTON SEWAGE TREATMENT PLANT

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HAMILTON SEWAGE TREATMENT PLANT

1.0 INTRODUCTION

The Ontario Ministry of Labour has prepared this brief report reviewing possible public health concerns resulting from the discharge of certain water-borne and air-borne contaminants from the Hamilton Sewage Treatment Plant (STP) in response to a request from the Ontario Ministry of the Environment. This request arose as a result of the submission of three research documents on the plant and the possible issues raised by them. (See Appendix). Where possible brief comments on the general environmental significance of these discharges will also be made.

Two of the three issues raised by the MOE - hazardous contaminant discharges in water and air - will be addressed. The third issue - changes in the leachability of hazardous contaminants resulting from anerobic digestion of sewage sludge - will not be discussed as the public health and/or environmental significance of such changes is not amenable to evaluation at the present time.

The ultimate evaluation of the public health and environmental significiance of certain contaminants present in the various effluents of the Hamilton STP is a formidable task. To complete this task even on a compound by compound basis (i.e. ignoring interactions) a number of facts should be known. These include:

- the total (ie. from all sources) contaminant loading in the region for each contaminant must be determined.

- the contribution of the plant to the total contaminant loading in the region for each contaminant and each discharge type (effluent and sludge incinerator stack emission) must be determined.

- the contribution of the plant to the public health concerns and environmental significance can then be related to the proportion of the loading it contributes for each contaminant.

This of course presumes that it is known at what concentration in the air, water, soil, foodstuffs and ultimately the human body, contaminants become public health and/or environmental hazards. Unfortunately this is the area where knowledge is most deficient and also most difficult to obtain.

An alternative approach to evaluating the hazard to health that may be due to contaminants is a comparison of the contaminant levels in air and water with occupational or environmental guidelines. Typically, environmental or occupational exposure guidelines are promulgated after due consideration of the scientific data available at the time. These guidelines represent the best professional judgement of contaminant levels that are relatively safe and thus may be used as a basis for estimating the public health and environmental safety of various contaminants. However, due to the large number of contaminants which must be assessed, guidelines have not yet been prepared for all compounds thus making this evaluation difficult even on this basis. Many of the contaminants of concern herein fall into this category.

Noting these very considerable difficulties, an attempt will be made to evaluate the public health and environmental significance of certain contaminants released from the Hamilton STP. The impact of the plant as a contaminant discharger will be put into perspective, qualitatively, for the local area. Where guidelines exist they will be used in an attempt to evaluate the major contaminants identified by the MOE. Where guidelines do not exist, toxicity data will be assembled for the contaminants in question and, where appropriate and feasible, comparisons will be made with the toxicity of similar contaminants for which guidelines do

exist. A review of the environmental fate of related contaminants will be included to aid these comparisons.

It must be stressed that this evaluation is by no means definitive in nature, it should be considered as a preliminary qualitative review of a very complex situation.

2.0 WATERBORNE CONTAMINANTS

Table 1 lists the hazardous contaminants identified in the MOE request along with their mean effluent concentration and various guideline levels from several jurisdictions. Estimated average daily and annual loading, based on a flow of 299,000 m^3/ day, are presented in Table 2.

2.1 Metals

Upon examining Table 1 it can be seen, with the exception of iron (which is based on staining not health considerations), that the levels of the metals examined are below those of Ontario's Drinking Water Objectives. In the case of Ontario's Ambient Surface Water Objectives the average levels of iron, copper, nickel, and zinc in the effluent from the STP exceed the recommended objectives, although the range of these exceedances is low, from about 1.2 to 3.7 times the respective limit. There are no guidelines for the concentration of metals in wastewater but as the metal levels generally meet the more stringent objectives, as noted above, the absence of effluent guidelines is not significant.

These effluent concentrations can also be put into perspective in another way, by comparing them with the naturally occuring concentrations of metals found in freshwater in Canada. Environment Canada (1978) provides information to enable this comparison to be made. Specifically, each metal is followed by its upper normal limit in fresh surface water expressed in mg/L: arsenic, 10; cadmium, 10; chromium, 1; copper, 50; lead, 40; mercury, 0.03; nickel, 100; selenium, 1; zinc, 50; aluminum, 1000; and iron, 500. With the exception of chromium, selenium and zinc, it can be seen that all metals present in the effluent water of the Hamilton STP are at concentrations below the upper limit of those found in natural waters. As noted above the levels of these 3 metals in the effluent do meet Ontario's Drinking Water Objectives.

There is some concern that although the metal levels in the effluent generally meet Ontario's Drinking and Surface Water Objectives the high flow from the plant averaging about 299,000 m^3/day produces a high net loading to the harbour area. OMOE (1985) notes that high metal levels in the water column and sediments of the harbour have been reported for some metals (in excess of Drinking/Ambient Surface Water Objectives and dredging guidelines, respectively, for some metals) and that although these levels are not sufficient to preclude human consumption, elevated levels of some metals have been reported in local fish.

The metals problem is largely local in nature as most of the metals join the sediment in the harbour and remain there. Transport of metals from the Hamilton Harbour does not represent a major environment problem for, putting the situation into perspective, the pollutants from Hamilton Harbour represent a minor contribution to Lake Ontario. The input is small compared to atmospheric input and the contribution of the Niagara River (OMOE 1985).

According to OMOE (1985) the Hamilton STP generates about 2% of the annual loading of iron to Hamilton Harbour in contrast to the industrial loading which represents about 95% of the annual loading. Clearly the STP is a very minor contributor in the case of iron and this also holds for several other metals and as well, many organics. As noted by OMOE (1985) the major source of heavy metals in Hamilton Harbour is not the Hamilton STP but rather industrial activities.

Thus, it must be concluded that although there does appear to be a problem with metal levels in the water and sediments of Hamilton Harbour the contribution of the Hamilton STP is very minor. If the STP was the only anthropogenic source of metals to the harbour it is not likely that any metal pollution problem would exist. Therefore, even with the current situation it appears that heavy metals discharged from the Hamilton STP in and of themselves do not represet

any significant public health concern nor do they have major environmental significance.

2.2 Organics

From Table 1 it can be seen that Water Quality Guidelines do not exist for many of the organic compounds in question. Ontario guidelines do exist for lindane, phenol and PCB's. Average lindane concentrations in the effluent water meets the drinking water objective but exceeds the ambient surface water objective by 3 times. Similarly, average PCB levels meet the Drinking Water but not the Ambient Surface Water Objectives. Dilution in the mixing zones of the discharge should reduce these levels, however the exact mixing zone values have not been estimated. OMOE (1985) notes that the Hamilton STP does not appear to be a major source of PCB's and other organochlorines and that the storm sewers seem to be a more likely candidate as a major source of the loading to Hamilton Harbour.

Average phenol levels in the effluent exceed both the Drinking Water and Surface Water objectives but as these objectives are set on the basis of organoleptic (taste and odour) characteristics of the compound, small exceedances should not represent a health hazard or environmental concern. For example the U.S. EPA has set objectives, based on aquatic and human health toxicity, about 3000 times higher than the Ontario objectives (Sittig, 1981).

Average pentachlorophenol levels in STP effluent are well below (about 20% of) the proposed OMOE ambient surface water criteria and are well below the World Health Organization guideline (as cited in the Appendix) for drinking water.

Surface water or drinking water objectives have not been established in Ontario for PAH's (polynuclear aromatic hydrocarbons, also called PNA's, polynuclear aromatics). As noted in the Appendix, the IJC and the World Health

Organization have suggested an objective of 0.01 µg/L for benzo(a)pyrene in surface and drinking waters, respectively. WHO also suggests an objective of 0.2 µg/L for certain PAH's as a group: fluoranthene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene and indeno(1,2,3,cd)pyrene. (IJC, 1983; Sittig, 1981). The U.S. EPA suggests a PAH drinking water objective for human health of 0.028 µg/L (for a 1 in 10,000 risk) based on the carcinogenicity potential of PAH's (Sittig 1981). The U.S. EPA considered naphthalene and fluoranthene separately, proposing a tenative aquatic guideline of 620 µg/L for the former and a human health guidelines of 42 µg/L, for the latter (U.S. EPA, 1980b,c).

The levels of naphthalene and fluoranthene in the STP effluent are well below the suggested U.S. EPA guidelines, but benzo(a)pyrene and PAH's as a group exceed the suggested guideline levels.

As effluent levels should not be judged on the basis of Ambient Surface and Drinking Water Guidelines and since PAH's levels in Hamilton Harbour water are not available, other means of assessment must be used.

Since, unlike the metals, organic chemical pollutants can be broken down by various environmental process, the aquatic fate of each compound is important in the evaluation of their environmental significance. The U.S.EPA (1979) provides an evaluation of the probable aquatic fate of a number of important pollutants. A summary of these findings is presented in Table 3. In Table 3 it can be seen that all of the organic compounds in question can be degraded by environmental processes; however, rates of degradation and the factors influencing these rates are not well known.

Biotransformation/biodegradation is a destruction pathway common to all the organic pollutants under study herein with most having at least one other significant breakdown pathway; for example photolysis. Although the rates of

degradation certainly vary with the compound in question and the environmental conditions, these processes ensure that substantial amounts of these organic compounds are broken down by natural processes thus lowering ambient levels of the parent compounds.

Also important to this evaluation are the various toxicological properties of the compounds; these are summarized in Table 4.

Based on a simple potency scale (Doull et al, 1980) the acute oral toxicity of the chemicals in question, when the information is available, fall in the extremely toxic-50 to 500 mg/kg - category (lindane, benzo(a)pyrene and pentachlorophenol) or the moderately toxic - 0.5 to 5 g/kg - category (the remaining organic chemicals). Although many of these chemicals are suspected carcinogens none have sufficient evidence to be classified as human carcinogens. Two - PCBs (some isomers) and benzo(a)pyrene have been shown to be animal carcinogens at relatively high exposure levels.

Another two chemicals - lindane and carbazole - have limited evidence to support animal carcinogenicity while the remainder have either no evidence suggesting carcinogenicity or inadequte evidence for valid evaluation. Only benzo(a)pyrene and fluoranthene appear to have significant mutagenic properties and none of the chemicals for which there is adequate data appears to have any teratogenic properties. Lindane, PCBs, benzo(a)pyrene, napthalene and pentachlorophenol have exhibited embryotoxic properties.

All of the effects observed above occurred at exposure concentrations many times those reported in the Hamilton STP effluent. Actual environmental levels would be even lower than values observed in the effluent due to dilution and degradation.

2.3 Discussion

Prior to a discussion of specific compounds with reference to Tables 1, 3 and 4, an evaluation of the general information on the total loadings of organic chemical compounds to the area will be presented to put this into perspective. The estimated loadings from the Hamilton STP are presented in Table 2. OMOE (1985) estimates that although the data set is limited it appears that the storm sewers are the primary source of PCBs and other organochlorine contaminants flowing into the harbour. OMOE (1985) also estimates that the steel mills are a major source of PAH loadings to the harbour. PAH input from the Hamilton STP is uncertain with estimates ranging from 10 to 50 per cent of the total loading to the harbour. The steel mills are also a major source of phenols. Finally, OMOE (1985) notes that, for many of the organic compounds in question, even when the total Hamilton Harbour input to Lake Ontario is considered, this contribution is very small relative to input from the atmosphere and the Niagara River.

Lindane:

Effluent levels are low and given the aquatic fate, together with available toxicological information the emission of this chemical from the Hamilton STP should not represent a human health hazard or an environmental concern.

PCBs:

Effluent levels are very low and are below Ontario drinking water standards. The effluent level, prior to mixing in the harbour exceeds ambient water guidelines; however, it appears that the Hamilton STP is a very minor contributor to the total loading of the harbour. Although PCBs have signficiant toxicological properties and some isomers are animal carcinogens, sufficient data for a regional evaluation do not exist. PCB discharges from the Hamilton STP should not be considered a significant hazard at this

time although data collection should continue, especially identification of the isomers present.

Phenol:

Although effluent phenol levels exceed both drinking and ambient water guidelines, those guidelines were set on the basis of organoleptic considerations. Dilution, and physical and biological degradation should rapidly reduce phenol concentrations to levels below the suggested guidelines; phenol emitted from the Hamilton STP does not appear to represent a significant health hazard or environmental concern.

Pentachlorophenol:

Pentachlorophenol concentrations in the effluent are below both the OMOE proposed guideline limit for ambient surface water and the World Health Organization drinking water guideline. Furthermore the toxicological properties and aquatic fate of pentachlorophenol suggests that discharges from the Hamilton STP do not appear to represent a significant health hazard or environmental concern.

Polynuclear Aromatic Hydrocarbons (PAH):

Although the Hamilton STP effluent levels of PAHs are very low relative to other STPs in Canada and the USA (see Table 1) the general lack of guidelines for PAHs makes evaluation difficult. On the basis of presently available toxicological information only benzo(a)pyrene (an animal carcinogen and mutagen), carbazole (limited evidence of carcinogenesis in animals) and possibly fluoranthene (a probable mutagen) appear to be of any possible concern at the present time. For the remaining PAHs there is no definite evidence of carcinogenicity, mutagenicity or teratogenicity. Reproductive effects have been noted but only at high exposure levels.

Sediment PAH levels are elevated several orders of magnitude above the background in the Hamilton Harbour area and although no standards exist to evaluate this, the increased fish PAH body burdens and higher incidences of tumours in fish in Hamilton Harbour may be related. Harbour sediment PAH distribution patterns suggest the steel mills are the most important source, although crude mass balance estimates suggest the STP may contribute from 10 to 50% of the harbour loading (OMOE 1985). Unfortunately this estimate does not include any contribution from the airborne pathway which is known to be considerable (coke-making is reported to be the highest anthropogenic source; IJC, 1983), so that it is likely that the contribution of the STP to total PAH loading to Hamilton Harbouris substantially lower than the 10-50% estimate.

As noted in Table 1 the IJC and World Health Organization recommend a maximum limit of 0.01 µg/L of benzo(a)pyrene in surface and drinking water. The World Health Organization also recommends a total level for PAHs of 0.2 µg/L (Sittig,1981). Although these levels are exceeded in the STP effluent the effluent is neither typical surface water nor drinking water. The WHO standards are more properly compared against typical environmental levels rather than tested drinking water; however, no ambient water level values for PAHs in Hamilton Habour are available, and, in fact OMOE (1985) reported the PAH levels in raw harbour water were below the detection limit which is of the order of 1 µg/L. PAH levels on suspended solids obtained from harbour water are available but back calculation to total water levels is very imprecise due to the unknown degree of partitioning between the suspended and dissolved phase. For example, IJC (1983) suggested that at a suspended solid level of 10 mg/L with a 10% organic carbon content some 60-95% of the PAH (depending on isomer hydrophobicity) will be in the dissolved phase. Therefore total estimated PAH water levels would range from about 0.04 to 0.25 µg/L.

However, these estimates are not necessarily reliable and the organic carbon partition coefficients may be as much as ten times too low, making the estimates of dissolved phase PAHs range from 30 to 90% rather than the 60-95% estimated above. Furthermore, the organic carbon content of Hamilton Harbour water may well be higher than the 10% value assumed above (OMOE 1985), which would further alter the estimates. Clearly under the current cirumstances it is virtually impossible to assess the situation with reference to the IJC and WHO water quality guidelines.

Due to a lack of information it is difficult to precisely determine if PAHs in Hamilton Harbour are a significant environmental concern and human health hazard. However, certain facts are noteworthy:

I. Municipal sewage effluent appears to be a minor contributor to PAH loadings to aquatic ecosystems.

II. The Hamilton STP effluent PAH levels are very low in comparison to others of its type (see Table 1);

III. The availability of PAHs in the water column is low especially as the bulk of the PAHs settle out in the bottom sediments;

IV. Many organisms can biodegrade PAHs which prevent bioconcentration to levels expected from their hydrophobicity charactertics.

V. Natural degradative processes continually break down emitted PAHs;

Although there may be some environmental concerns relative to the total PAH loadings and levels in Hamilton Harbour, it is unlikely that the PAHs emitted in the effluent wastewater of the Hamilton STP in and of themselves represent a significant human health hazard or environmental concern at this time.

3.0 AIRBORNE CONTAMINANTS

The airborne contaminants of concern along with their average percentage destruction, hourly discharge rate, and worst case ground level concentration (D stability, calculated by MOE staff) are presented in Table 5. This information as well as the annual atmospheric PAH loading estimate from the Hamilton STP - 60 kg per year - was taken from Bridle et al., 1984.

No Ontario ambient air guidelines currently exist for PAHs, although Coke Oven Emissions are designated in Ontario under the Occupational Health and Safety Act with an occupational exposure limit of 0.15 mg/m^3 of benzene soluble material. In the USA occupational human health guidelines from OSHA and NIOSH suggest a limit of 0.1 to 0.15 mg/m^3 for emissions from coke ovens and coal tars (Sittig, 1981). The ACGIH suggests a limit of 0.2 mg/m^3 for the total benzene soluble fraction. No ambient air guidelines for PAHs have been formulated in the USA.

PCBs are also emitted from the Hamilton STP and since both occupational and ambient air guidelines have been formulated for them a brief review of the pertinent data may be informative. PCB's are emitted from the STP at an hourly rate of about 1.1 g/h resulting in a maximum ground concentration (D stability) of 0.78 ng/m^3. This is well below the Ontario ambient air guidelines of 450 ng/m^3 for ½ hour peak, 150 ng/m^3 daily average and 35 ng/m^3 annual average. By comparison occupational guidelines for PCBs in the USA range from 0.5 to 2.0 mg/m^3 (Sittig, 1981).

3.1. Fate of Airborne Contaminants

PAH's are highly reactive compounds which are subject to degradation by a variety of chemical and physical factors: sunlight, ozone, singlet oxygen, and other constituents of urban smog. Reaction rates vary widely depending on the PAH in question and the ambient conditions but half-lives for the compounds in the atmosphere are generally estimated to be of the order of hours or at the most a few days. (Radding et al.1976).

3.2 Toxicity

Toxicity information is presented in Table 4 and has largely been discussed in the previous section on waterborne contaminants. However, since no ambient air guidelines exist for the PAH's of concern, only very general, qualitative statements can be made.

3.3 Discussion

Only the significance of the estimated ground level concentrations of PAH's will be discussed as evaluation of the STPs contribution to the total PAH loading in the Hamilton area is not possible with the information at hand. However, given the multitude of natural and anthropogenic sources of PAH's (Grimmer, 1983) it is doubtful that the the STP could represent anything more than a minor contributor to the load in the local area.

With regards to acute toxicity none of the PAHs in question appear to be of concern as doses required to generate responses are massive with respect to the ground level concentrations expected. Clearly, long-term or chronic toxicity is of primary concern. Of the group of seven of concern with respect to air contamination only benzo(a)pyrene (an animal carcinogen and mutagen) and carbazole (a mutagen) have any evidence supporting significant long-term toxicity. The embryotoxicity reported

for some of these compounds occurs at relatively high exposure levels. If we consider that all of the PAHs measured are equitoxic with the most toxic (benzo(a)pyrene), a very conservative procedure, then the total ground level concentration of PAHs would be 37 ng/m^3.

This level is well below occupational guidelines. Where ambient air guidelines have not been formulated occupational standards can be used as a starting point for estimating an ambient level, although this approach can only provide a rough guide when other information is unavailable. Essentially appropriate adjustments are made to compensate for the change from intermittent exposure (40 work hours per 168 hour week) to continuous exposure. An adjustment factor of 40h/168h = .24 plus an additional safety factor of about 10 generates a correction factor of about 0.02 (rounded). Applied to the most stringent guideline suggested earlier - for coke oven emissions/coal tars 0.1 mg/m^3 - the method suggests that an acceptable level for total PAHs in air is about 2 $\mu g/m^3$ or 2000 ng/m^3. This level is well above (by about two orders of magnitude) the maximum estimated ground concentration of PAHs presented earlier.

Although total background PAH levels are not available for the Hamilton area Grimmer (1983) reports that background benzo(a)pyrene levels in the Hamilton area have been measured at concentrations ranging from 5.7 to 9.4 ng/m^3. Table 5 indicates that only dibenzofuran and fluoranthene might exceed typical ambient air levels of PAHs measured in the Hamilton Area.

On the basis of the above arguments it appears that the estimated ground level concentrations of PAHs in the vicinity of the Hamilton Sewage Treatment Plant (the worst case) do not appear to represent a significant human health hazard or environmental concern.

TABLE 3

SUMMARY OF AQUATIC FATES OF SELECTED ORGANIC COMPOUNDS[1]

	Photolysis	Oxidation	Hydrolysis	Volatilization	Sorption	Bioaccumulation	Biotransformation/ Biodegradation
Lindane	Probably not important (PNI)	PNI	PNI	PNI	Important for transport to anaerobic sediments	not significant	most important; rapid in anerobic environments
Polychlorinated Biphenyls	may break down heavier PCB's	not important	not important	important for transport; reduced by organics	strongly absorbed to solids, especially organics	yes, bioaccumulation factors of 10^4-10^6	important but only for PCB's with less than 4 chlorines per molecule
Pentachlorophenol	probably important near surface of water	thought to be important	thought to important	PNI	absorbed to organic material	yes, bioaccumulation factor about $10^{3.5}$	important
Phenol	probably important near surface of water	limited	not relevant	limited	not significant	not significant	very important
Polynuclear Aromatic Hydrocarbons (as a group)	dissolved portion may undergo rapid photolysis	slow process not significant	not important	minor importance as a transport process	strongly absorbed to suspended solids, an important transport process	short-term process due to rapid metabolic breakdown of PAH's with less than 4-5 rings	probably ultimate fate as PAH's with less than 4 rings are readily metabolized by biota

Reference:

Callahan et al., 1979.

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APPENDIX

Information Provided by
Ministry of Environment

Ministry of the Environment
Ontario

Initiation of a Request for Medical Advice

Date: February 21, 1985

Requested by Region/Branch	Originator's Name	Telephone
Water Resources	Jim Bishop	965-0141

Location: 1 St. Clair Avenue West, 4/F

Previous MOL Contact for this Request: Dr. G. Wright, Special Studies and Services, 400 University Avenue, 8/F

Date Required:	Reason for Date:
April 19, 1985	The attached report is scheduled for publication in April, 1985

Request:

To advise MOE on potential Public Health impacts/concerns due to continuous discharge of hazardous contaminants in Hamilton Sewage Treatment Plant (STP) effluents and incinerator stack gases. The incidence of hazardous contaminants in these two sources are reported in both concentrations (parts per billion) and in daily loadings (Kg/day

Extent of Problem: (Exposure)

Hamilton STP effluent eventually drains into Lake Ontario. There are public bathing beaches, yacht clubs and a Drinking Water Treatment plant situated near the STP. There is a significant number of people working and living in the vicinities of the STP. These people are, therefore, constantly exposed to the incinerator stack emission.

Chronological History:

Chemical Agents Suspected:

acenaphthylene, benzo-(a)-pyrene, flourene, fluoranthene, Naphthalene, pyrene, carbazole, dibenzofuran, lindane, phenol, pentachlorophenol, total PCB's, iron, aluminum, arsenic, cadmium, chromium, copper, mercury, magnesium, nickel, lead, selenium, zinc.

☐ Supporting Information Attached

☐ Forthcoming Information, List

0877 7/83

Table 1: Removal of Selected Organics and Heavy Metals in Hamilton STP

	Average % Removal at Hamilton STP (%)	Average Conc. in Hamilton STP Effluents (ug/L)	Conc. Ranges Reported in Literature[1] (ug/L)	Ontario Objectives for Drinking Water (ug/L)	Ontario Objectives for Ambient Surface Water (ug/L)
Arsenic	85	0.12	<2 - 80	50	100
Cadmium	92	0.08	<1 - 1800	5	0.2
Chromium	92	18.2	<3 - 6950	50	100
Copper	89	18.4	7 - 2300	1,000	5[2]
Lead	95	6.2	<10 - 2540	50	5 - 25
Mercury	83	0.03	<0.1 - 7	1	0.2
Nickel	60	37.1	<5 - 5970	-	25[2]
Selenium	86	8.8	<1 - 10	10	100
Zinc	81	91.3	<2 - 9250	5,000	30[2]
Aluminum[3]	84	363	-	-	-
Iron[3]	93	489	-	300[2]	300[2]
Lindane	70	0.03	<0.02 - 3.9	4	0.01[2]
PCB's	90	0.03	<0.45 - 49.6	3	0.001[2]
Pentachlorophenol	63	0.10	<1 - 630	10[5]	-
Phenol	89	5.0	<1 - 1400	2[2]	1[2]
Naphthalene	97	0.28	<1 - 380	-	-
Acenaphthylene	100	0.04	<1 - 6	-	-
Dibenzofuran	95	0.12	-	-	-
Fluorene	97	0.19	<1 - 62	-	-
Pyrene	95	0.80	<1 - 25	-	-
Benzo(a)pyrene	99	0.62	<5 - 10	0.01[2,5]	.01[2,4]
Fluoranthene	96	0.61	-	-	-
Carbazole	98	0.41	-	-	-

NOTES:

(1) Concentrations in final effluents reported for 22 Canadian STP's and 50 US STP's. Results derived from A Review of the Municipal Abatement Programs in the Great Lakes Basin (IJC Task Force Report), August, 1983.
(2) The given standard was exceeded by the concentration in Hamilton STP effluent.
(3) Aluminum and iron are not included in the EPA 126 priority pollutants.
(4) Is not an Ontario Objective but is recommended by IJC for protection of aquatic life.
(5) Is not an Ontario Objective but is recommended by WHO for Drinking Water Guidelines.